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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES

In Re Application of:	)	
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BOHN, David, D.	)	
	)	Examiner: Luu, T.X.
Serial No. 09/220,736	)	
	)	Group Art Unit: 2878
Filing Date: December 23, 1998	)	
	)	
For: OPTICAL SYSTEM FOR COMPENSATING FOR NON-UNIFORM ILLUMINATION OF AN OBJECT	)	

APPEAL BRIEF

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APPEAL BRIEF

To: The Commissioner of Patents and Trademarks
Washington, D.C. 20231

Sir:

This Appeal Brief is submitted in response to the final rejections of the claims dated April 12, 2001. A Notice of Appeal was filed on July 9, 2001.

REAL PARTY IN INTEREST

The assignee of the entire right, title, and interest in the patent application is Hewlett-Packard Company.

RELATED APPEALS AND INTERFERENCES

There are currently no related appeals or interferences known to appellant, appellant's legal representative, or the assignee which will directly affect, or be directly affected by, or have a bearing on, the Board's decision.

STATUS OF THE CLAIMS

Claims 1-17 are pending in the application. Claims 1-17 are rejected. The rejections of claims 1-17 are appealed.

STATUS OF AMENDMENTS

On June 1, 2001, appellants filed a request for reconsideration under 37 C.F.R. 1.116 in response to the final office action. In an advisory action, dated June 19, 2001, the examiner confirmed that claims 1-17 continue to stand rejected.

SUMMARY OF INVENTION

The present invention is directed to an optical system (10) for compensating for non-uniform illumination of an object (16), that is, an object that is unevenly illuminated so that the object has a brightly illuminated region (e.g., region 38 in Figure 5) and a less-brightly illuminated region (e.g., region 40 in Figure 5). The optical system of the present invention involves a combination of a telecentric lens assembly (36) and an occluding element (54) that results in a transmittance function (e.g., 56, Figure 9) for the optical system that compensates for the uneven illumination of the object. For example, if the optical system (10) is used to form an image of an illuminated region (28) on an object (16) having a brightly illuminated central region (38) and a less brightly illuminated periphery (40), the result will be an image that will appear to the sensor as if it were more uniformly illuminated than is actually the case.

Stated simply, the optical system (10) compensates for the non-uniform illumination of the object by having a high transmittance for areas that correspond to the less brightly illuminated regions (40) on the object and a reduced transmittance for areas that correspond to the brightly illuminated regions (38) on the object.

The invention as claimed is summarized below with reference numerals and reference to the specification and drawings.

(Claim 1) An optical system (10, Figures 1, 2 and 7, p. 7, l. 17 - p. 12, l. 9; p. 13, l. 17 - p. 25, l. 5) for forming an image of at least a portion of an illuminated area (28, Figures 4, 5, and 7, p. 8, l. 11 - p. 10, l. 6; p. 16, l. 29 - p. 17, l. 18; p. 19, l. 7 - l. 26) on an object (16, Figures 1, 4, and 7, p. 7, l. 28 - p. 8, l. 10; p. 13, l. 17 - p. 14, l. 3), the illuminated area (28) being characterized by at least one brightly illuminated region (38, Figures 5 and 7, p. 8, l. 33 - p. 10, l. 6; p. 19, l. 7 - p. 20, l. 13) and at least one less brightly illuminated region (40, Figures 5 and 7, p. 8, l. 33 - p. 10, l. 6; p. 19, l. 7 - p. 20, l. 13), comprising:

a lens (36, Figures 4, 7, and 8, p. 10, l. 7 - l. 27; p. 20, l. 14 - p. 21, l. 12) positioned a spaced distance from the illuminated area (28) on the object (16), said lens (36) having an image side focal plane (48, Figure 7, p. 10, l. 7 - l. 27; p. 20, l. 14 - p. 21, l. 12);

an aperture stop (46, Figures 4 and 7, p. 10, l. 14 - 27; p. 20, l. 21 - 31) positioned so that it is substantially co-planar with the image side focal plane (48) of said lens (36); and

an occluding element (54, Figures 7 and 8, p. 10, l. 28 - p. 12, l. 9; p. 21, l. 19 - p. 25, l. 6) positioned between said lens (36) and the illuminated area (28) on the object (16) so that said occluding element (54) blocks a predetermined amount of light (32, Figure 7, p. 10, l. 21-27; p. 21, l. 19 - 24) from the brightly illuminated region (38) but does not substantially block light (32) from the less brightly illuminated region (40).

(Claim 2) The optical system (10) of claim 1, wherein said lens (36) includes an object side surface (52, Figures 7 and 8, p. 10, l. 21 - 27; p. 20, l. 26 - 31; p. 21, l. 19 - p. 25, l. 6) and wherein said occluding element (54) is positioned adjacent the object side surface (52) of said lens (36).

(Claim 3) The optical system (10) of claim 2, wherein said occluding element (54) comprises an opaque material deposited on the object side surface (52) of said lens (36).

(Claim 4) The optical system (10) of claim 1, further comprising a window (44, Figures 4 and 7, p. 10, l. 10 - 14; p. 20, l. 18 - 21; p. 21, l. 13 - 18) positioned between the object side surface (52) of said lens (36) and the illuminated area (28) on the object (16), said window (44) having an object side surface (96, Figure 7, p. 21, l. 27 - 29; p. 22, l. 8 - 13; p. 24, l. 32 - p. 25 l. 1) and a lens side surface (98 Figure 7, p. 21, l. 27 - 29; p. 22, l. 8 - 13; p. 24, l. 32 - p. 25 l. 1).

(Claim 5) The optical system (10) of claim 4, wherein said occluding element (54) is positioned adjacent the lens side surface (98) of said window (44) (p. 21, l. 19 - p. 25, l. 6).

(Claim 6) The optical system (10) of claim 5, wherein said occluding element (54) comprises an opaque material deposited on the lens side surface (98) of said window (44) (p. 21, l. 19 - p. 25, l. 6).

(Claim 7) The optical system (10) of claim 1, wherein said occluding element (54) comprises a substantially circular shape (Figure 8).

(Claim 8) An optical system (10, Figures 1, 2 and 7, p. 7, l. 17 - p. 12, l. 9; p. 13, l. 17 - p. 25, l. 5) for forming an image of at least a portion of an illuminated area (28, Figures 4, 5, and 7, p. 8, l. 11 - p. 10, l. 6; p. 16, l. 29 - p. 17, l. 18; p. 19, l. 7 - l. 26) on an object (16, Figures 1, 4, and 7, p. 7, l. 28 - p. 8, l. 10; p. 13, l. 17 - p. 14, l. 3), the illuminated area (28) being characterized by at least one brightly illuminated region (38, Figures 5 and 7, p. 8, l. 33 - p. 10, l. 6; p. 19, l. 7 - p. 20, l. 13) and at least one less brightly illuminated region (40, Figures 5 and 7, p. 8, l. 33 - p. 10, l. 6; p. 19, l. 7 - p. 20, l. 13), comprising:

lens means (36, Figures 4, 7, and 8, p. 10, l. 7 - l. 27; p. 20, l. 14 - p. 21, l. 12) positioned a spaced distance from the object (16) for forming an image of at least a portion of the illuminated area (28) on the object (16);

telecentric aperture stop means (46, Figures 4 and 7, p. 10, l. 14 - 27; p. 20, l. 21 - 31)

operatively associated with said lens means (36) for blocking selected light rays refracted by said lens means (36); and

occluding means (54, Figures 7 and 8, p. 10, l. 28 - p. 12, l. 9; p. 21, l. 19 - p. 25, l. 6) positioned between said lens means (36) and the object (16) for blocking a predetermined amount of light (32, Figure 7, p. 10, l. 21- 27; p. 21, l. 19 - 24) from the brightly illuminated region (38) but not substantially blocking light (32) from the less brightly illuminated region (40).

(Claim 9) A method of forming an image of at least a portion of an illuminated area (28, Figures 4, 5, and 7, p. 8, l. 11 - p. 10, l. 6; p. 16, l. 29 - p. 17, l. 18; p. 19, l. 7 - l. 26) on an object (16, Figures 1, 4, and 7, p. 7, l. 28 - p. 8, l. 10; p. 13, l. 17 - p. 14, l. 3), the illuminated area (28) being characterized by at least one brightly illuminated region (38, Figures 5 and 7, p. 8, l. 33 - p. 10, l. 6; p. 19, l. 7 - p. 20, l. 13) and at least one less brightly illuminated region (40, Figures 5 and 7, p. 8, l. 33 - p. 10, l. 6; p. 19, l. 7 - p. 20, l. 13), comprising:

positioning a lens (36, Figures 4, 7, and 8, p. 10, l. 7 - l. 27; p. 20, l. 14 - p. 21, l. 12) a spaced distance from the illuminated area (28) on the object (16), said lens (36) having an image side focal plane (48, Figure 7, p. 10, l. 7 - l. 27; p. 20, l. 14 - p. 21, l. 12);

positioning an aperture stop (46, Figures 4 and 7, p. 10, l. 14 - 27; p. 20, l. 21 - 31) at about the image side focal plane (48) of said lens (36); and

blocking a predetermined amount of light (32, Figure 7, p. 10, l. 21- 27; p. 21, l. 19 - 24) from the brightly illuminated region (38) before the light (32) from the brightly illuminated region (38) is refracted by said lens (36).

(Claim 10) A navigation system (12, Figures 1, 2 and 7, p. 7, l. 17 - p. 12, l. 9; p. 13, l. 17 - p. 25, l. 5) for an image sensing device (14, Figures 1 and 2, p. 7, l. 17 - p. 8, l. 10; p. 13, l. 17 - p. 15, l. 19), said navigation system (12) producing a navigation signal related to navigation light (32, Figure 7, p. 10,

l. 21- 27; p. 21, l. 19 - 24) received from an illuminated navigation area (28, Figures 4, 5, and 7, p. 8, l. 11 - p. 10, l. 6; p. 16, l. 29 - p. 17, l. 18; p. 19, l. 7 - l. 26) on an object (16, Figures 1, 4, and 7, p. 7, l. 28 - p. 8, l. 10; p. 13, l. 17 - p. 14, l. 3), the illuminated navigation area (28) being characterized by at least one brightly illuminated region (38, Figures 5 and 7, p. 8, l. 33 - p. 10, l. 6; p. 19, l. 7 - p. 20, l. 13) and at least one less brightly illuminated region (40, Figures 5 and 7, p. 8, l. 33 - p. 10, l. 6; p. 19, l. 7 - p. 20, l. 13), comprising:

a detector (34, Figures 4 and 7, p. 8, l. 18 - 32; p. 10, l. 7 - 27; p. 16, l. 29 - p. 19, l. 6; p. 20, l. 14 - 31);

a lens (36, Figures 4, 7, and 8, p. 10, l. 7 - l. 27; p. 20, l. 14 - p. 21, l. 12) having an image side focal plane (48, Figure 7, p. 10, l. 7 - l. 27; p. 20, l. 14 - p. 21, l. 12), said lens (36) being positioned between said detector (34) and the illuminated navigation area (28) on the object (16) so that said lens (36) forms on said detector (34) an image of at least a portion of the illuminated navigation area (28);

an aperture stop (46, Figures 4 and 7, p. 10, l. 14 - 27; p. 20, l. 21 - 31) positioned so that it is substantially co-planar with the image side focal plane (48) of said lens (36); and

an occluding element (54, Figures 7 and 8, p. 10, l. 28 - p. 12, l. 9; p. 21, l. 19 - p. 25, l. 6) positioned between said lens (36) and the illuminated area (28) on the object (16) so that said occluding element (54) blocks a predetermined amount of navigation light (32, Figure 7, p. 10, l. 21- 27; p. 21, l. 19 - 24) from the brightly illuminated region (38) but does not substantially block navigation light (32) from the less brightly illuminated region (40).

(Claim 11) The navigation system (12) of claim 10, wherein said lens (36) includes an object side surface (52, Figures 7 and 8, p. 10, l. 21 - 27; p. 20, l. 26 - 31; p. 21, l. 19 - p. 25, l. 6) and wherein said occluding element (54) is positioned adjacent the object side surface (52) of said lens (36).

(Claim 12) The navigation system (12) of claim 11, wherein said occluding element (54)

comprises an opaque material deposited on the object side surface (52) of said lens (36).

(Claim 13) The navigation system (12) of claim 10, further comprising a window (44, Figures 4 and 7, p. 10, l. 10 - 14; p. 20, l. 18 - 21; p. 21, l. 13 - 18) positioned between the object side surface (52) of said lens (36) and the illuminated area (28) on the object (16), said window (44) having an object side surface (96, Figure 7, p. 21, l. 27 - 29; p. 22, l. 8 - 13; p. 24, l. 32 - p. 25 l. 1) and a lens side surface (98, Figure 7, p. 21, l. 27 - 29; p. 22, l. 8 - 13; p. 24, l. 32 - p. 25 l. 1).

(Claim 14) The navigation system (12) of claim 13, wherein said occluding element (54) is positioned adjacent the lens side surface (98) of said window (44) (p. 21, l. 19 - p. 25, l. 6).

(Claim 15) The navigation system (12) of claim 14, wherein said occluding element (54) comprises an opaque material deposited on the lens side surface (98) of said window (44) (p. 21, l. 19 - p. 25, l. 6).

(Claim 16) The navigation system (12) of claim 10, wherein said occluding element (54) comprises a substantially circular shape (Figure 8).

(Claim 17) A navigation system (12, Figures 1, 2 and 7, p. 7, l. 17 - p. 12, l. 9; p. 13, l. 17 - p. 25, l. 5) for producing a navigation signal related to navigation light (32, Figure 7, p. 10, l. 21- 27; p. 21, l. 19 - 24) received from an illuminated navigation area (28, Figures 4, 5, and 7, p. 8, l. 11 - p. 10, l. 6; p. 16, l. 29 - p. 17, l. 18; p. 19, l. 7 - l. 26) on an object (16, Figures 1, 4, and 7, p. 7, l. 28 - p. 8, l. 10; p. 13, l. 17 - p. 14, l. 3), the illuminated navigation area (28) being characterized by at least one brightly illuminated region (38, Figures 5 and 7, p. 8, l. 33 - p. 10, l. 6; p. 19, l. 7 - p. 20, l. 13) and at least one less brightly illuminated region (40, Figures 5 and 7, p. 8, l. 33 - p. 10, l. 6; p. 19, l. 7 - p. 20, l. 13), comprising:

detector means (34, Figures 4 and 7, p. 8, l. 18 - 32; p. 10, l. 7 - 27; p. 16, l. 29 - p. 19, l. 6; p. 20, l. 14 - 31) for producing an output signal related to light incident thereon;

lens means (36, Figures 4, 7, and 8, p. 10, l. 7 - l. 27; p. 20, l. 14 - p. 21, l. 12) positioned between said detector means (34) and the object (16) for forming on said detector (34) an image of at least a portion of the illuminated navigation area (28);

telecentric aperture stop means (46, Figures 4 and 7, p. 10, l. 14 - 27; p. 20, l. 21 - 31) operatively associated with said lens means (36) for blocking selected navigation light rays (32, Figure 7, p. 10, l. 21- 27; p. 21, l. 19 - 24) refracted by said lens means (36); and

occluding means (54, Figures 7 and 8, p. 10, l. 28 - p. 12, l. 9; p. 21, l. 19 - p. 25, l. 6) positioned between said lens means (36) and the object (16) for blocking a predetermined amount of navigation light (32) from the brightly illuminated region (38) but not substantially blocking navigation light (32) from the less brightly illuminated region (40).

ISSUES

1. Whether claims 1-3 and 7-9 are unpatentable under 35 U.S.C. §102(b) as being anticipated by Matsunami or Thomson.

2. Whether claims 4-6 and 10-17 are unpatentable under 35 U.S.C. §103(a) as being obvious over Matsunami or Thomson.

GROUPING OF THE CLAIMS

None of the claims stand or fall together. Each claim is patentable on independent grounds as set forth in the ARGUMENT.

ARGUMENT

Opening Statement

Neither Matsunami nor Thomson disclose an aperture stop positioned so that it is substantially

co-planar with the image side focal plane of the lens. That is, neither reference discloses a telecentric optical system. Since this limitation is not met, neither Matsunami nor Thomson can anticipate claims 1-3 and 7-9 under Section 102. With respect to the obviousness rejections of claims 4-6 and 10-17 under Section 103, neither Matsunami nor Thomson provides the suggestion or incentive required to modify either reference in a manner that would make obvious the rejected claims.

Appellant's Invention

Appellant's invention is directed to an optical system for use with hand-held scanners having optical position sensing or "navigation" systems. In one embodiment, the optical system comprises a portion of the "navigation" system and compensates for non-uniform illumination of a navigation region contained on the object being scanned. Accordingly, the scanner navigation system "sees" the navigation region as if it were more uniformly illuminated than is actually the case, thereby improving performance.

Background

Optical scanner devices are well-known in the art and may be used to produce machine-readable image data signals that are representative of a scanned object, such as a photograph or a page of printed text. In a typical scanner application, the image data signals produced by an optical scanner may be used by a personal computer to reproduce an image of the scanned object on a suitable display device, such as a CRT or a printer.

A hand-held or portable optical scanner is an optical scanner which is designed to be moved by hand across the object or document being scanned. The hand-held scanner may be connected directly to a separate computer by a data cable. If so, the data signals produced by the hand-held scanner may be transferred to the separate computer "on the fly," i.e., as the image data are collected. Alternatively, the hand-scanner may include an on-board data storage system for storing the image data. The image data may then be downloaded to a separate computer after the scanning operation is complete via any convenient means, such as a cable or an optical infrared data link.

A typical hand-held optical scanner may include illumination and optical systems to accomplish scanning of the object. The illumination system illuminates a portion of the object (commonly referred to as a "scan region"), whereas the optical system collects light reflected by the illuminated scan region and focuses a small area of the illuminated scan region (commonly referred to as a "scan line") onto the surface of a photosensitive detector positioned within the scanner. Image data representative of the entire object then may be obtained by sweeping the scan line across the entire object, usually by moving the hand-held scanner with respect to the object. By way of example, the illumination system may include a plurality of light emitting diodes (LEDs), although other types of light sources, such as fluorescent or incandescent lamps, may also be used. The optical system may include a "contact image sensor" or CIS to focus the image of the illuminated scan line onto the surface of the detector. Alternatively, a lens and/or mirror assembly may be used to collect and focus light from the illuminated scan region onto the detector.

The hand-held scanner device may be provided with a position sensing or "navigation" system in order to determine the position of the hand-held scanner with respect to the object being scanned. Accordingly, such a position sensing system allows the scanner to correlate its position with respect to the object being scanned. The position correlation allows a complete image of the scanned object to be produced even though the scanner may not scan the entire object during a single pass or "swipe." For example, if two or more swipes of the object are required to scan the entire object, then the position correlation provided by the navigation system will allow the various portions of the scanned image data to be "stitched" together to form a single unitary image representative of the entire scanned object.

One type of navigation system utilizes a pair of optical sensors to detect certain inherent structural features (e.g., surface roughness, paper fiber orientation, etc.) contained on the object being scanned (e.g., a sheet of paper with text or images thereon). Examples of the foregoing type of navigation system are disclosed in U.S. Patent No. 5,089,712 of Holland for "Sheet Advancement Control System Detecting Fiber Pattern of Sheet," and U.S. Patent No. 5,578,813 of Allen, *et al.*, for "Freehand Image Scanning Device which Compensates for Non-Linear Movement."

While such navigation systems are known and are being used, they are not without their problems. For example, one problem associated with optical navigation systems of the type described above stems from the difficulty in uniformly illuminating the inherent structural features on the object so that the same may be detected by the navigation sensors. The light sources typically used to illuminate the navigation areas (e.g., infra-red light emitting diodes (LEDs)) typically do not provide a uniform illumination pattern. Consequently, the illuminated navigation area may comprise one or more brightly illuminated regions and one or more less-brightly illuminated regions. If the difference between the brightly illuminated regions and the less brightly illuminated regions is substantial, there is a significant chance that the navigation system will interpret the non-uniformity of illumination as fixed pattern noise, which may result in the navigation system producing a false navigation signal. Such false navigation signals may well result in erroneous position values which may make it impossible for the image data processing system to successfully stitch together the various image portions captured during the various scanning swipes.

One solution to the non-uniform illumination problem described above is to provide the light source with one or more lenses or reflectors to better distribute and focus the light onto the navigation area. Unfortunately, such lens or reflector systems may be difficult to fabricate and align and, in any event, tend to add considerably to the overall cost of the scanner. Partly in an effort to avoid the foregoing problems, most optical navigation systems utilize LEDs having integral lenses of the type that are well-known and readily commercially available. While the integral lens design avoids the problems associated with providing separate lenses or reflectors, the quality of most such integral lens arrangements is generally quite poor, and it is not uncommon for the illumination patterns produced by such integral lens LEDs to contain substantial non-uniformities. Indeed, the quality of the illumination provided by such integral lens LEDs is generally barely sufficient to allow for the consistent and reliable operation of the scanner navigation system.

<u>Discussion of the References</u>

1. Matsunami *et al.*, U.S. Patent No. 5,022,725 (Matsunami). The Matsunami reference discloses an optical sensor or radiometer for detecting an ambient light level. Matsunami's arrangement provides for more accurate sensing of an ambient light level in that the resulting output is not too heavily weighted toward light incident on the sensor at small angles, e.g., such as light from the sun if the sensor is pointed at the sky. The sensor comprises a lens 5 and a light detector 6 that is provided with a transmitting window 7 and a sensing element 8. The sensor utilizes a light ray shielding section 9 located on the optical axis of the lens 5 that is symmetrical with respect thereto. The shielding section 9 reduces the amount of light reaching the detector 6 that is incident at small angles with respect to the optical axis of the lens 5. This has the effect of increasing the sensitivity of the detector 6 to light that is incident at larger angles (e.g., 45° - 90°) with respect to the optical axis. See, for example, Figure 12 of Matsunami. This compares with the response characteristic of a conventional radiometer illustrated in Figure 15.

2. Thomson, U.S. Patent No. 3,825,747 (Thomson) discloses a scanner having combined transmitting and receiving units. The scanner uses a single lens 14 to form the outgoing illumination or source beam and to focus the reflected or returned beam onto a sensor 16. In one embodiment, the lens 14 is positioned within a tube 12. The lens 14 is provided with a convex surface and a plane surface and is positioned within the tube 12 so that the plane surface faces the light source 10. The plane surface of the lens 14 is provided with a disk 20, the forward-facing surface of which is reflective and the rearward-facing surface of which is opaque to light from the light source 10. The plane surface of lens 14 is also provided with a forward reflecting surface 44. The arrangement is such that the light produced by the light source 10 is formed into an outgoing beam by the lens 14 and such that the return beam is twice passed through the lens 14 before being incident on the sensor 16. The disk 20, being opaque to the light produced by the light source 10, shields the sensor 16 from receiving light directly from the light source 10.

ISSUE 1: WHETHER CLAIMS 1-3 AND 7-9 ARE UNPATENTABLE UNDER 35 U.S.C. §102(b) AS BEING ANTICIPATED BY MATSUNAMI OR THOMSON.

Claims 1-3 and 7-9 currently stand rejected under Section 102(e) as being anticipated by Matsunami or, in the alternative, by Thomson.

Legal Standard For Rejecting Claims Under 35 U.S.C. §102

The standard for lack of novelty, that is, for "anticipation," under 35 U.S.C. §102 is one of strict identity. To anticipate a claim for a patent, a single prior source must contain all its essential elements. *Hybritech, Inc. v. Monoclonal Antibodies, Inc.*, 231 USPQ 81, 90 (Fed. Cir. 1986). Invalidity for anticipation requires that all of the elements and limitations of the claims be found within a single prior art reference. *Scripps Clinic & Research Foundation v. Genentech, Inc.*, 18 USPQ2d 1001 (Fed. Cir. 1991). Furthermore, functional language, preambles, and language in "whereby," "thereby," and "adapted to" clauses cannot be disregarded. *Pac-Tec, Inc. v. Amerace Corp.*, 14 USPQ2d 1871 (Fed. Cir. 1990).

The Examiner's Rejections

The examiner rejected claims 1-3 and 7-9 under 35 U.S.C. §102(b) as being anticipated by Matsunami or, in the alternative, by Thomson. It is the position of the examiner that both of these references disclose each and every element and meet each and every limitation set forth in claims 1-3 and 7-9. The examiner's rejections are improper in that neither reference discloses elements that are specifically required by the rejected claims.

Each of the currently pending claims requires that an aperture be positioned so that it is substantially co-planar with the image side focal plane of the lens. Claims 1-3, 7, and 9 each recite this requirement specifically. Claim 8 uses different language to describe what is inherently the same limitation. That is, claim 8 requires a "telecentric aperture stop means." By definition, a telecentric aperture stop is located so that it is substantially co-planar with the image side focal plane of the lens.

See, for example, page 10, lines 17-27 of the currently pending application:

> "The location of the aperture 46 at about the image side focal plane 48 of lens 36 makes the lens assembly 36 telecentric. Accordingly, the aperture 46 may be referred to herein in the alternative as a "telecentric aperture." As a result of the telecentric lens configuration, the cones of light 32 reflected by various illuminated field points 50 contained within the illuminated navigation area 28 on the object 16 remain relatively well-separated in the region between the object 16 and the front or object side surface 52 of lens assembly 36. See Figure 7."

The "telecentric aperture stop means" recited in claim 8 inherently includes the limitation that the aperture be positioned at about the image side focal plane of the lens.

The Matsunami reference does not disclose an arrangement wherein the aperture stop is positioned so that it is substantially co-planar with the image side focal plane of the lens. Consequently, Matsunami cannot anticipate claims 1-3 and 7-9 of the present invention.

Matsunami discloses an optical sensor having reduced sensitivity along the optical axis of the lens. This arrangement reduces the sensitivity of the sensor to light that is incident on the lens at small angles with respect to the optical axis while increasing the sensitivity to light incident at large angles. See, for example, Figure 12 of Matsunami. While Matsunami places a transmitting window 7 between the lens 5 and the optical sensor element 8, the transmitting window 7 is not positioned so that it is substantially co-planar with the image side focal plane of the lens. To the contrary, the window 7 in the Matsunami device functions as a field stop, not an aperture stop. As is well-known in the optics field, a field stop limits the field of view of an optical system, whereas an aperture stop limits the amount of light that is allowed to enter the system. The aperture stop in Matsunami is effectively the diameter of the lens 5. Since Matsunami's aperture stop is in fact the lens 5 itself, Matsunami cannot meet the limitation of the currently pending claims that requires the aperture stop to be located so that it is substantially co-planar with the image side focal plane of the lens.

While it is true that the Matsunami reference does not specify the precise location of the window 7, Matsunami also does not specify that the window be located at about the image side focal plane of the lens. Vague or uncertain teachings of the prior art cannot support an anticipation rejection under Section 102. *W.L. Gore & Assoc. v. Garlock, Inc.*, 721 F.2d 1540, 220 USPQ 303 (Fed. Cir. 1983).

The Thomson reference also fails to disclose an optical system wherein the aperture is located so that it is substantially co-planar with the image side focal plane of the lens. That is, Thomson does not disclose a telecentric optical system. As discussed above, the Thomson reference discloses a scanner having combined transmitting and receiving units. The scanner uses a single lens 14 to form the outgoing illumination or source beam and to focus the reflected or returned beam onto a sensor 16. The lens 14 is provided with a convex surface and a plane surface and is positioned within the tube 12 so that the plane surface faces the light source 10. The plane surface of the lens 14 is provided with a disk 20, the forward-facing surface of which is reflective and the rearward-facing surface of which is opaque to light from the light source 10. The plane surface of lens 14 is also provided with a forward reflecting surface 44. The arrangement is such that the light produced by the light source 10 is formed into an outgoing beam by the lens 14 and such that the return beam is twice passed through the lens 14 before being incident on the sensor 16. The disk 20, being opaque to the light produced by the light source 10, shields the sensor 16 from receiving light directly from the light source 10. Thomson does not locate the aperture at the image side focal plane of the lens, nor does Thomson teach using a telecentric aperture, in combination with an occluding element, to compensate for uneven illumination of an object.

In conclusion, neither Matsunami nor Thomson can anticipate claims 1-3 and 7-9 since neither Matsunami nor Thomson teach or suggest a limitation specifically contained in those claims. That is, neither Matsunami nor Thomson teach or suggest positioning an aperture at about the image side focal plane of the lens. That is, neither Matsunami nor Thomson teach a system for compensating for uneven illumination of an object that includes a telecentric optical system.

It follows, then, that neither Matsunami nor Thomson anticipates claim 1. That is, neither reference discloses:

> "An optical system for forming an image of at least a portion of an illuminated area on an object, the illuminated area being characterized by at least one brightly illuminated region and at least one less brightly illuminated region, comprising:
>
> a lens positioned a spaced distance from the illuminated area on the object, said lens

having an image side focal plane;

an aperture stop positioned so that it is substantially co-planar with the image side focal plane of said lens; and

an occluding element positioned between said lens and the illuminated area on the object so that said occluding element blocks a predetermined amount of light from the brightly illuminated region but does not substantially block light from the less brightly illuminated region."

Claim 2 is believed to be allowable on further independent grounds in that the references do not disclose or suggest:

"The optical system of claim 1, wherein said lens includes an object side surface and wherein said occluding element is positioned adjacent the object side surface of said lens."

Claim 3 is believed to be allowable on further independent grounds in that the references do not disclose or suggest:

"The optical system of claim 2, wherein said occluding element comprises an opaque material deposited on the object side surface of said lens."

Claim 7 is believed to be allowable on further independent grounds in that the references do not disclose or suggest:

"The optical system of claim 1, wherein said occluding element comprises a substantially circular shape."

With regard to independent claim 8, appellant repeats the arguments for allowability stated for claim 1, above, but specifically directed to the optical system set forth in the claim. That is, the references do not disclose or make obvious:

"An optical system for forming an image of at least a portion of an illuminated area on an object, the illuminated area being characterized by at least one brightly illuminated region and at least one less brightly illuminated region, comprising:

lens means positioned a spaced distance from the object for forming an image of at least a portion of the illuminated area on the object;

<u>telecentric aperture stop means operatively associated with said lens means for blocking selected light rays refracted by said lens means</u>; and

occluding means positioned between said lens means and the object for blocking a predetermined amount of light from the brightly illuminated region but not substantially blocking light from the less brightly illuminated region."

With regard to independent claim 9, appellant repeats the arguments for allowability stated for claim 1, above, but specifically directed to the method set forth in the claim. That is, the references do not disclose or make obvious:

"A method of forming an image of at least a portion of an illuminated area on an object, the illuminated area being characterized by at least one brightly illuminated region and at least one less brightly illuminated region, comprising:

positioning a lens a spaced distance from the illuminated area on the object, said lens having an image side focal plane;

<u>positioning an aperture stop at about the image side focal plane of said lens</u>; and

blocking a predetermined amount of light from the brightly illuminated region before the light from the brightly illuminated region is refracted by said lens."

ISSUE 2: WHETHER CLAIMS 4-6 AND 10-17 ARE UNPATENTABLE UNDER 35 U.S.C. §103(a) AS BEING OBVIOUS OVER MATSUNAMI OR THOMSON.

Claims 4-6 and 10-17 currently stand rejected under Section 103(a) as being obvious over

Matsunami or, in the alternative, Thomson.

Legal Standard For Rejecting Claims Under 35 U.S.C. §103

The test for obviousness under 35 U.S.C. §103 is whether the claimed invention would have been obvious to those skilled in the art in light of the knowledge made available by the reference or references. *In re Donovan*, 184 USPQ 414, 420, n. 3 (CCPA 1975). It requires consideration of the entirety of the disclosures of the references. *In re Rinehart*, 189 USPQ 143, 146 (CCPA 1976). All limitations of the claims must be considered. *In re Boe*, 184 USPQ 38, 40 (CCPA 1974). In making a determination as to obviousness, the references must be read without benefit of applicant's teachings. *In re Meng*, 181 USPQ 94, 97 (CCPA 1974). In addition, the propriety of a Section 103 rejection is to be determined by whether the reference teachings appear to be sufficient for one of ordinary skill in the relevant art having the references before him to make the proposed substitution, combination, or other modifications. *In re Lintner*, 173 USPQ 560, 562 (CCPA 1972).

A basic mandate inherent in Section 103 is that a piecemeal reconstruction of prior art patents shall not be the basis for a holding of obviousness. It is impermissible within the framework of Section 103 to pick and choose from any one reference only so much of it as will support a given position, to the exclusion of other parts necessary to the full appreciation of what such reference fairly suggests to one of ordinary skill in the art. *In re Kamm*, 172 USPQ 298, 301-302 (CCPA 1972). Put somewhat differently, the fact that the inventions of the references and of the applicant may be directed to concepts for solving the same problem does not serve as a basis for arbitrarily choosing elements from references to attempt to fashion applicant's claimed invention. *In re Donovan, supra*, at 420.

In the case of *In re Wright*, 6 USPQ2d 1959 (Fed. Cir. 1988) (restricted on other grounds by *In re Dillon*, 16 USPQ2d 1897 (Fed. Cir. 1990), the Court of Appeals for the Federal Circuit decided that the Patent Office had improperly combined references which did not suggest the properties and results of the applicants' invention nor suggest the claimed combination as a solution to the problem which

applicants' invention solved. The CAFC reached this conclusion after an analysis of the prior case law, at p. 1961:

> "We repeat the mandate of 35 U.S.C.§ 103: it is the invention as a whole that must be considered in obviousness determinations. The invention as a whole embraces the structure, its properties, and the problem it solves. See, e.g., *Cable Electric Products, Inc. v. Genmark, Inc.*, 770 F.2d 1015, 1025, 226 USPQ 881, 886 (Fed. Cir. 1985) ("In evaluating obviousness, the hypothetical person of ordinary skill in the pertinent art is presumed to have the 'ability to select and utilize knowledge from other arts reasonably pertinent to [the] particular problem' to which the invention is directed"), quoting *In re Angle*, 444 F.2d 1168, 1171-72, 170 USPQ 285, 287-88 (CCPA 1971); *In re Antonie*, 559 F.2d 618, 619, 195 USPQ 6, 8 (CCPA 1977) ("In delineating the invention as a whole, we look not only at the claim in question... but also to those properties of the subject matter which are inherent in the subject matter **and** are disclosed in the Specification") (emphasis in original).
>
> The determination of whether a novel structure is or is not "obvious" requires cognizance of the properties of that structure and the problem which it solves, viewed in light of the teachings of the prior art. See, e.g., *In re Rinehart*, 531 F.2d 1048, 1054, 189 USPQ 143, 149 (CCPA 1976) (the particular problem facing the inventor must be considered in determining obviousness); see also *Lindemann Maschinenfabrik GmbH v. American Hoist and Derrick Co.*, 730 F.2d 1452, 1462, 221 USPQ 481, 488 (Fed. Cir. 1984) (it is error to focus "solely on the product created, rather than on the obviousness or notoriousness of its creation") (quoting *General Motors Corp. v. U.S. Int'l Trade Comm'n*, 687 F.2d 476, 483, 215 USPQ 484, 489 (CCPA 1982), cert. denied, 459 U.S. 1105 (1983).
>
> Thus the question is whether what the inventor did would have been obvious to one of ordinary skill in the art attempting to solve the problem upon which the inventor was working. *Rinehart*, 531 F.2d at 1054, 189 USPQ at 149; see also *In re Benno*, 768 F.2d 1340, 1345, 226 USPQ 683, 687 (Fed. Cir. 1985) ("appellant's problem" and the prior art present different problems requiring different solutions")."

A reference which teaches away from the applicant's invention may not properly be used in framing a 35 U.S.C. §103 rejection of applicant's claims. See *United States v. Adams*, 148 USPQ 429 (1966).

The Examiner's Rejections

The examiner rejected claims 4-6 and 10-17 under Section 103(a) as being obvious over Matsunami or, in the alternative, Thomson. These rejections are improper in that neither Matsunami nor Thomson provides the suggestion or incentive that would be required to combine them in a manner that would make obvious the rejected claims. Therefore, neither reference can be used to support an obviousness rejection under Section 103.

The Matsunami reference discloses a sensor or radiometer having increased sensitivity to light that is incident on the detector at large angles with respect to the optical axis of the lens. Matsunami does not teach or suggest using a telecentric optical system in combination with an occluding element to achieve this result. In fact, nowhere does Matsunami use the term "telecentric" nor does Matsunami specify the location of the window with respect to the focal plane of the lens. In sum, Matsunami does not teach, or even suggest, positioning an aperture so that it is substantially co-planar with the image side focal plane of the lens.

Another difference between the Matsunami device and that of the claims of the present invention is that the Matsunami device is not an imaging device. That is, the lens 5 of Matsunami does not form an image on the sensor 6. Instead, the lens 5 merely directs light onto the sensor 6 so that the sensor 6 can determine a total amount of light or radiation surrounding the lens. Stated another way, Matsunami's lens provides only an out-of-focus or "de-focused" image on the sensor. In contrast, the optical system of the present invention is an imaging device and forms an image on the detector.

The Thomson reference discloses a scanner having its own light source 10 for illuminating an object to be detected or scanned. Thomson arranges the optical system in such a manner that the light produced by the light source 10 is not directly incident on the detector 16. Thomson does not disclose a telecentric optical system. While Thomson does disclose a window (not identified by a reference number) and an opaque material deposited on the lens to help shield the detector from the light rays produced by the light source 10, neither element, nor Thomson's entire arrangement, provides the suggestion or incentive to rearrange them to form the optical system that meets the limitations of the rejected claims. Stated another way, the problems solved by Thomson, i.e., that of providing a coaxial beam scanner wherein the sensor is shielded from receiving light directly from the light source) are so far removed from the problems solved by the present invention that a person having ordinary skill in the art would not view Thomson as having any particular relevance to the problems recognized and solved by the present invention.

Appellant notes that it is well-established patent law that most, if not all inventions arise from

a combination of old elements. See *In re Rouffet*, 149 F.3d 1350, 1357, 47 USPQ2d 1453, 1457 (Fed. Cir. 1998). Thus, every element of a claimed invention may often be found in the prior art. *See id.* However, identification in the prior art of each individual part claimed is insufficient to defeat patentability of the whole claimed invention. *See id.* Rather, to establish obviousness based on a combination of the elements disclosed in the prior art, there must be some motivation, suggestion or teaching of the desirability of making the specific combination that was made by the appellant. *In re Kotzab*, 55 USPQ 2d 1313, 1316 (Fed. Cir. 2000). Even when obviousness is based on a single prior art reference, there must be a showing of a suggestion or motivation to modify the teachings of that reference. *See id.*

With regard to the foregoing points, appellant has demonstrated that neither Matsunami nor Thomson provide the suggestion or motivation required to make the modifications urged by the examiner. The fact that Matsunami or Thomson <u>could</u> be modified to include certain elements recited in the claims is insufficient since neither reference provides the suggestion or incentive to do so.

The hypothetical "person having ordinary skill in the art" is a person that thinks along the lines of conventional wisdom and is not one who undertakes to innovate, whether by extraordinary insights or by patient and often expensive systematic research. *Standard Oil Co. v. American Cyanamid Co.*, 774 F.2d 448, 227 USPQ 293 (Fed. Cir. 1985). A person having ordinary skill in the art looking to either Matsunami or Thomson to solve the problem of compensating for non-uniform illumination of an object would see no need to selectively modify either device in order to come up with the device defined by the currently pending claims.

To summarize, in making his rejections the examiner has ignored the teachings (and limitations to those teachings) of both Matsunami and Thomson and has instead utilized the appellant's own invention as a guide for picking and choosing from among those references only those elements and limitations that are contained in the claims. Such an activity amounts to hindsight reconstruction and cannot be used to support a valid obviousness rejection under Section 103.

In summation, none of the references, taken singly or in combination, disclose each and every

element set forth in claim 4. That is, the references do not disclose or make obvious:

"The optical system of claim 1, further comprising a window positioned between the object side surface of said lens and the illuminated area on the object, said window having an object side surface and a lens side surface."

Claim 5 is believed to be allowable on further independent grounds in that the references do not disclose or suggest:

"The optical system of claim 4, wherein said occluding element is positioned adjacent the lens side surface of said window."

Claim 6 is believed to be allowable on further independent grounds in that the references do not disclose or suggest:

"The optical system of claim 5, wherein said occluding element comprises an opaque material deposited on the lens side surface of said window."

With regard to independent claim 10, appellant repeats the arguments for allowability stated above, but specifically directed to the apparatus set forth in the claim. That is, the references do not disclose or make obvious:

"A navigation system for an image sensing device, said navigation system producing a navigation signal related to navigation light received from an illuminated navigation area on an object, the illuminated navigation area being characterized by at least one brightly illuminated region and at least one less brightly illuminated region, comprising:

a detector;

a lens having an image side focal plane, said lens being positioned between said detector and the illuminated navigation area on the object so that said lens forms on said detector an image of at least a portion of the illuminated navigation area;

an aperture stop positioned so that it is substantially co-planar with the image side focal plane of said lens; and

an occluding element positioned between said lens and the illuminated area on the object so that said occluding element blocks a predetermined amount of navigation light from the brightly illuminated region but does not substantially block navigation light from the less brightly illuminated region."

Claim 11 is believed to be allowable on further independent grounds in that the references do not disclose or suggest:

"The navigation system of claim 10, wherein said lens includes an object side surface and wherein said occluding element is positioned adjacent the object side surface of said lens."

Claim 12 is believed to be allowable on further independent grounds in that the references do not disclose or suggest:

"The navigation system of claim 11, wherein said occluding element comprises an opaque material deposited on the object side surface of said lens."

Claim 13 is believed to be allowable on further independent grounds in that the references do not disclose or suggest:

"The navigation system of claim 10, further comprising a window positioned between the object side surface of said lens and the illuminated area on the object, said window having an object side surface and a lens side surface."

Claim 14 is believed to be allowable on further independent grounds in that the references do not disclose or suggest:

"The navigation system of claim 13, wherein said occluding element is positioned

adjacent the lens side surface of said window."

Claim 15 is believed to be allowable on further independent grounds in that the references do not disclose or suggest:

"The navigation system of claim 14, wherein said occluding element comprises an opaque material deposited on the lens side surface of said window."

Claim 16 is believed to be allowable on further independent grounds in that the references do not disclose or suggest:

"The navigation system of claim 10, wherein said occluding element comprises a substantially circular shape."

With regard to independent claim 17, appellant repeats the arguments for allowability stated above, but specifically directed to the navigation system set forth in the claim. That is, the references do not disclose or make obvious:

"A navigation system for producing a navigation signal related to navigation light received from an illuminated navigation area on an object, the illuminated navigation area being characterized by at least one brightly illuminated region and at least one less brightly illuminated region, comprising:

detector means for producing an output signal related to light incident thereon;

lens means positioned between said detector means and the object for forming on said detector an image of at least a portion of the illuminated navigation area;

telecentric aperture stop means operatively associated with said lens means for blocking selected navigation light rays refracted by said lens means; and

occluding means positioned between said lens means and the object for blocking a predetermined amount of navigation light from the brightly illuminated region but not

substantially blocking navigation light from the less brightly illuminated region."

CONCLUSION

Claims 1-3 and 7-9 are not anticipated by either the Matsunami reference nor the Thomson reference since neither reference discloses an optical system having an aperture positioned at about the image side focal plane of the lens. With respect to the examiner's obviousness rejections of claims 4-6 and 10-17, neither Matsunami nor Thomson provide the suggestion or incentive that would have been required to motivate a person having ordinary skill in the art, with no knowledge of the present invention, to modify either reference in a manner that would have made obvious the currently pending claims. Therefore, neither Matsunami nor Thomson can support the examiner's obviousness rejections under Section 103. Accordingly, appellant urges the Board to reverse the examiner's rejections of claims 1-17.

Respectfully submitted,

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Date: 5-3-02

APPENDIX A

1. An optical system for forming an image of at least a portion of an illuminated area on an object, the illuminated area being characterized by at least one brightly illuminated region and at least one less brightly illuminated region, comprising:

a lens positioned a spaced distance from the illuminated area on the object, said lens having an image side focal plane;

an aperture stop positioned so that it is substantially co-planar with the image side focal plane of said lens; and

an occluding element positioned between said lens and the illuminated area on the object so that said occluding element blocks a predetermined amount of light from the brightly illuminated region but does not substantially block light from the less brightly illuminated region.

2. The optical system of claim 1, wherein said lens includes an object side surface and wherein said occluding element is positioned adjacent the object side surface of said lens.

3. The optical system of claim 2, wherein said occluding element comprises an opaque material deposited on the object side surface of said lens.

4. The optical system of claim 1, further comprising a window positioned between the object side surface of said lens and the illuminated area on the object, said window having an object side surface and a lens side surface.

5. The optical system of claim 4, wherein said occluding element is positioned adjacent the lens side surface of said window.

6. The optical system of claim 5, wherein said occluding element comprises an opaque material deposited on the lens side surface of said window.

7. The optical system of claim 1, wherein said occluding element comprises a substantially circular shape.

8. An optical system for forming an image of at least a portion of an illuminated area on an object, the illuminated area being characterized by at least one brightly illuminated region and at least one less brightly illuminated region, comprising:

lens means positioned a spaced distance from the object for forming an image of at least a portion of the illuminated area on the object;

telecentric aperture stop means operatively associated with said lens means for blocking selected light rays refracted by said lens means; and

occluding means positioned between said lens means and the object for blocking a predetermined amount of light from the brightly illuminated region but not substantially blocking light from the less brightly illuminated region.

9. A method of forming an image of at least a portion of an illuminated area on an object, the illuminated area being characterized by at least one brightly illuminated region and at least one less brightly illuminated region, comprising:

positioning a lens a spaced distance from the illuminated area on the object, said lens having an image side focal plane;

positioning an aperture stop at about the image side focal plane of said lens; and

blocking a predetermined amount of light from the brightly illuminated region before the light from the brightly illuminated region is refracted by said lens.

10. A navigation system for an image sensing device, said navigation system producing a navigation signal related to navigation light received from an illuminated navigation area on an object, the illuminated navigation area being characterized by at least one brightly illuminated region and at least one less brightly illuminated region, comprising:

a detector;

a lens having an image side focal plane, said lens being positioned between said detector and the illuminated navigation area on the object so that said lens forms on said detector an image of at least a portion of the illuminated navigation area;

an aperture stop positioned so that it is substantially co-planar with the image side focal plane of said lens; and

an occluding element positioned between said lens and the illuminated area on the object so that said occluding element blocks a predetermined amount of navigation light from the brightly illuminated region but does not substantially block navigation light from the less brightly illuminated region.

11. The navigation system of claim 10, wherein said lens includes an object side surface and wherein said occluding element is positioned adjacent the object side surface of said lens.

12. The navigation system of claim 11, wherein said occluding element comprises an opaque material deposited on the object side surface of said lens.

13. The navigation system of claim 10, further comprising a window positioned between the object side surface of said lens and the illuminated area on the object, said window having an object side surface and a lens side surface.

14. The navigation system of claim 13, wherein said occluding element is positioned

adjacent the lens side surface of said window.

15. The navigation system of claim 14, wherein said occluding element comprises an opaque material deposited on the lens side surface of said window.

16. The navigation system of claim 10, wherein said occluding element comprises a substantially circular shape.

17. A navigation system for producing a navigation signal related to navigation light received from an illuminated navigation area on an object, the illuminated navigation area being characterized by at least one brightly illuminated region and at least one less brightly illuminated region, comprising:

detector means for producing an output signal related to light incident thereon;

lens means positioned between said detector means and the object for forming on said detector an image of at least a portion of the illuminated navigation area;

telecentric aperture stop means operatively associated with said lens means for blocking selected navigation light rays refracted by said lens means; and

occluding means positioned between said lens means and the object for blocking a predetermined amount of navigation light from the brightly illuminated region but not substantially blocking navigation light from the less brightly illuminated region.

APPENDIX B
References Relied on By Examiner in his Final Response.

A copy of each reference is attached hereto for the Board's convenience.

1. Matsunami *et al.*, U.S. Patent No. 5,022,725, issued June 11, 1991, entitled "Optical Sensor."

2. Thomson, U.S. Patent No. 3,825,747, issued July 23, 1974, entitled "Scanner."

United States Patent [19]

Matsunami et al.

[11] Patent Number: 5,022,725

[45] Date of Patent: Jun. 11, 1991

[54] OPTICAL SENSOR

[75] Inventors: Takao Matsunami, Hirakata; Hidenori Okuda, Shiga, both of Japan

[73] Assignee: Matsushita Electric Industrial Co., Ltd., Osaka, Japan

[21] Appl. No.: 423,087

[22] Filed: Oct. 18, 1989

[30] Foreign Application Priority Data

Oct. 21, 1988 [JP] Japan 63-266389

[51] Int. Cl.[5] G02B 17/00

[52] U.S. Cl. 350/1.4; 350/442; 350/502; 250/216

[58] Field of Search 350/1.4, 442, 444, 445, 350/446, 502; 250/216

[56] References Cited

U.S. PATENT DOCUMENTS

3,825,747	7/1974	Thomson	250/216
4,055,761	10/1977	Shimomura	250/216
4,554,448	11/1985	Sillitto	350/442
4,880,974	11/1989	Yamakawa	250/216

Primary Examiner—Bruce Y. Arnold
Assistant Examiner—J. D. Ryan
Attorney, Agent, or Firm—Panitch Schwarze Jacobs & Nadel

[57] ABSTRACT

An optical sensor comprising a light detector, a converging lens located between the light detector and a light source, the light rays from which are detected by the light detector, and a light shielding means provided on a part of the converging lens, the shielding means shielding light rays emitted from the light source, thereby reducing dependence of the amount of light rays to be detected upon angles of incidence with which the light rays enter into the converging lens of the optical sensor.

4 Claims, 11 Drawing Sheets

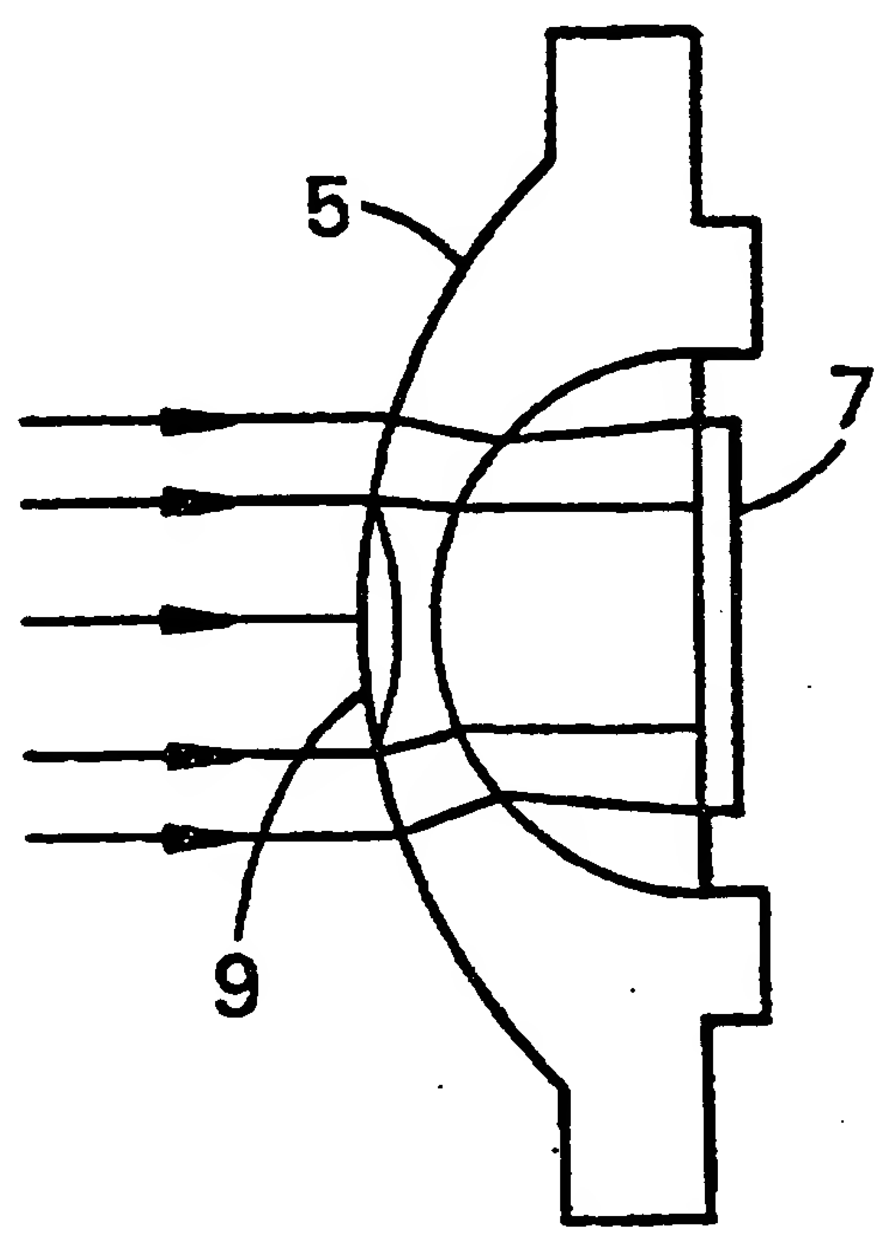


FIG. 1

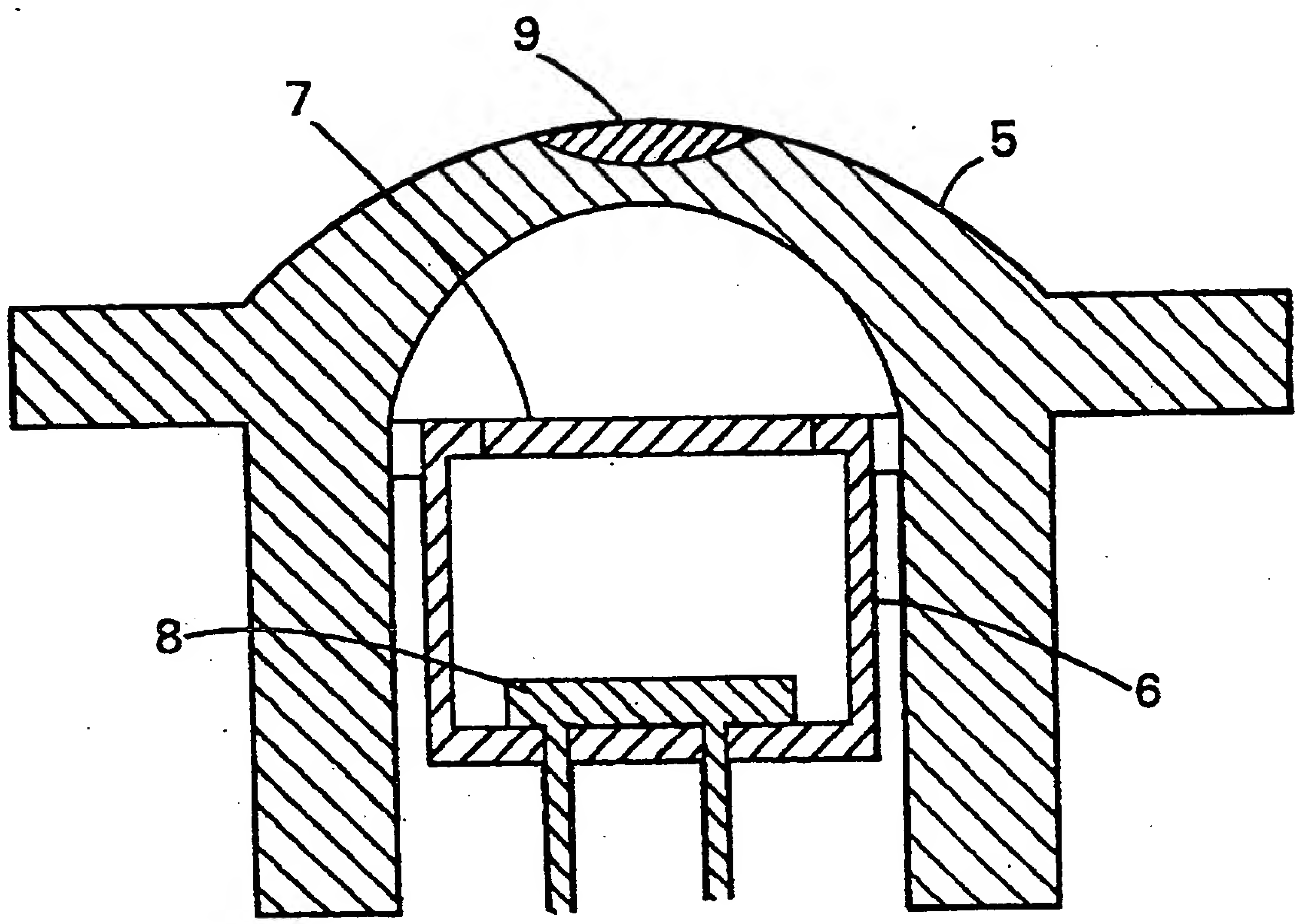


FIG. 2a

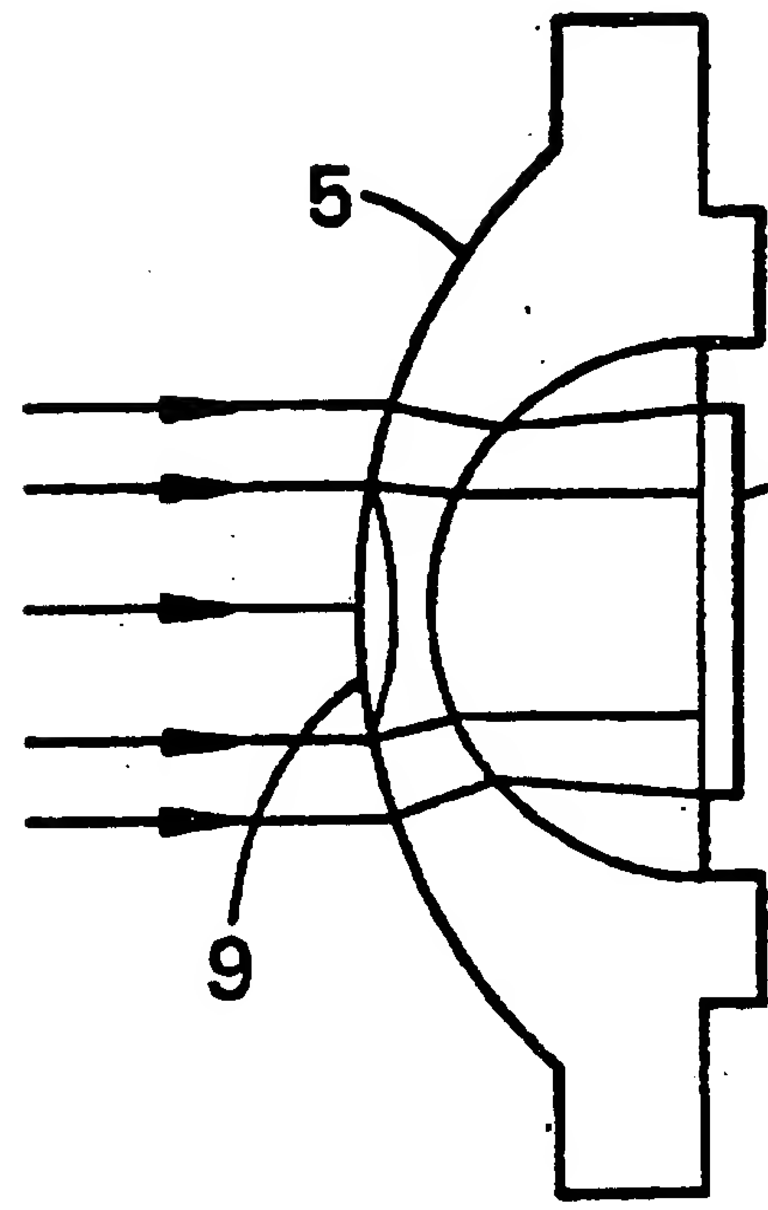


FIG. 2c

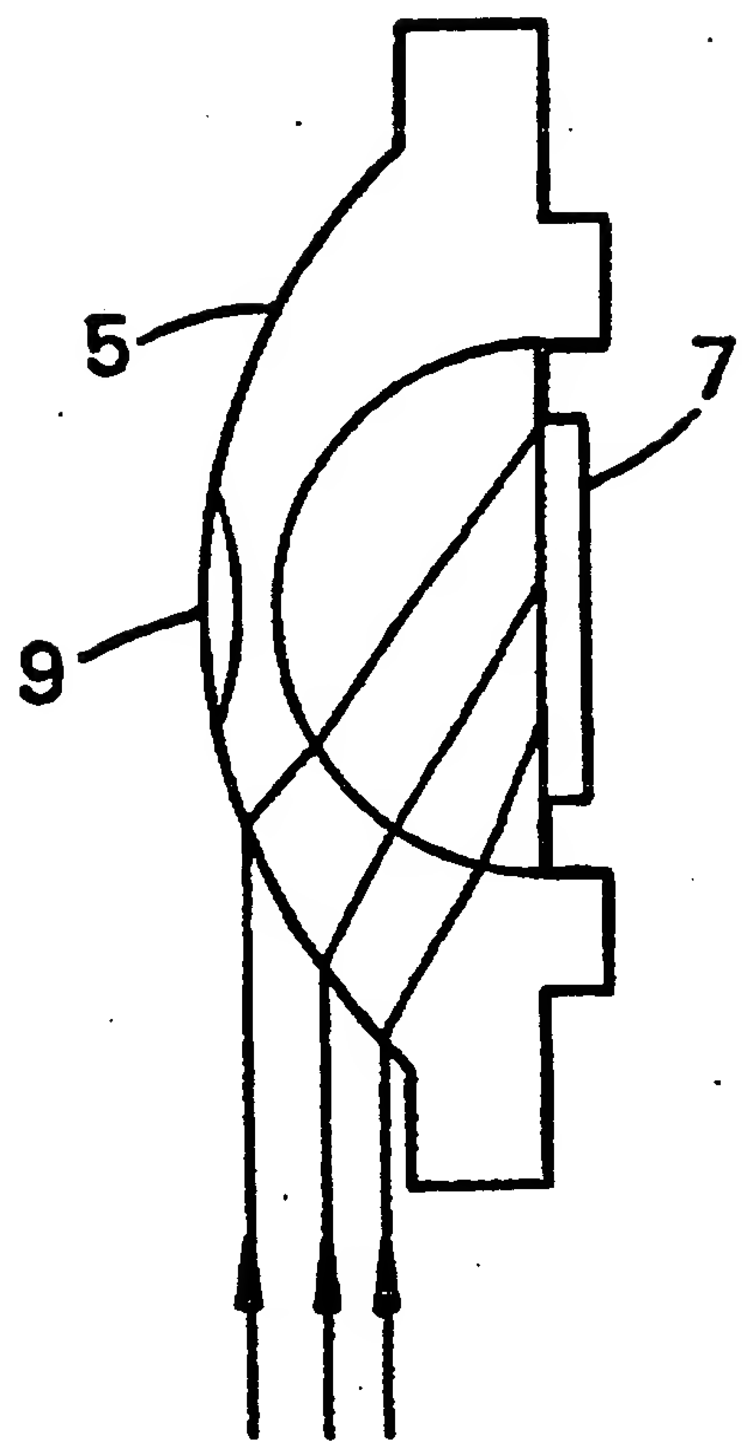


FIG. 2b

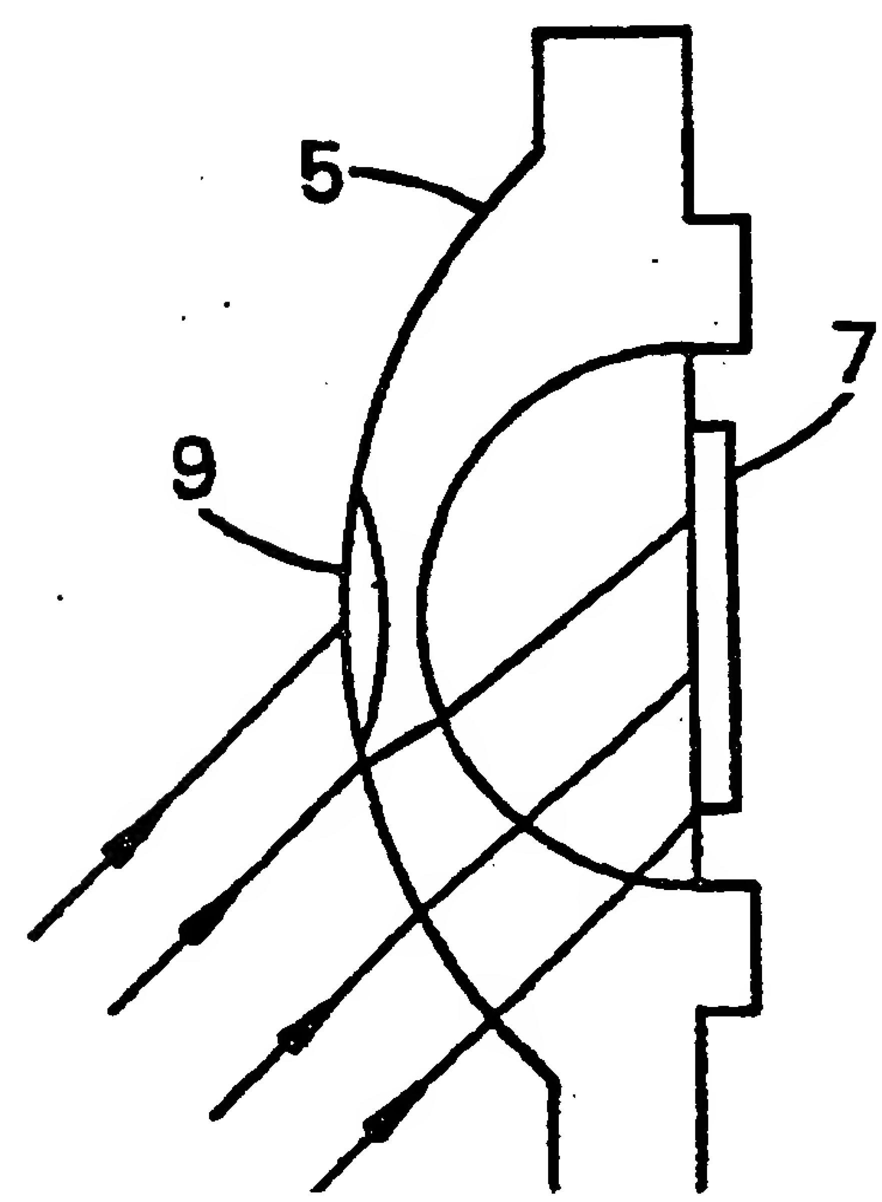


FIG. 4a

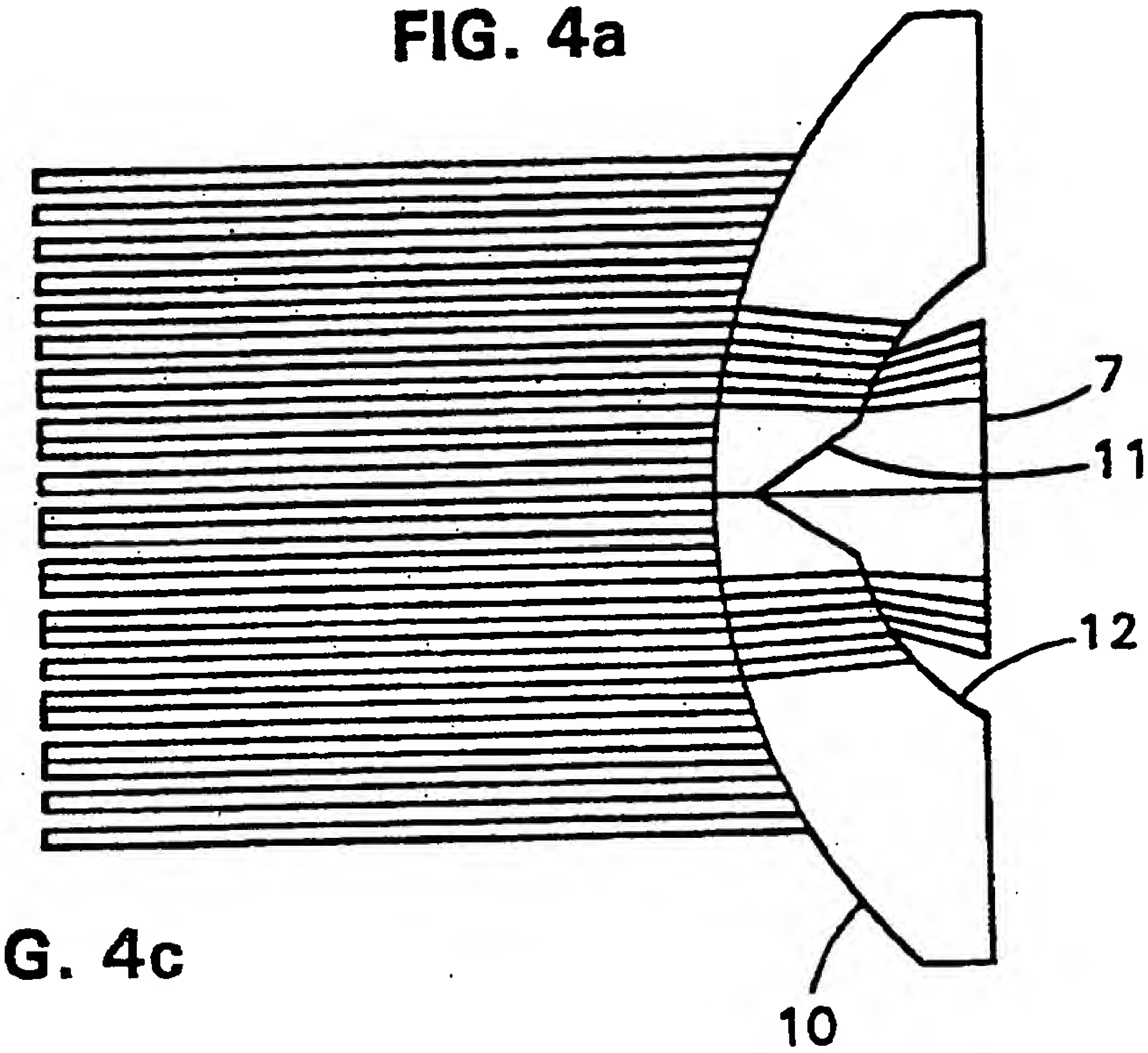


FIG. 4c

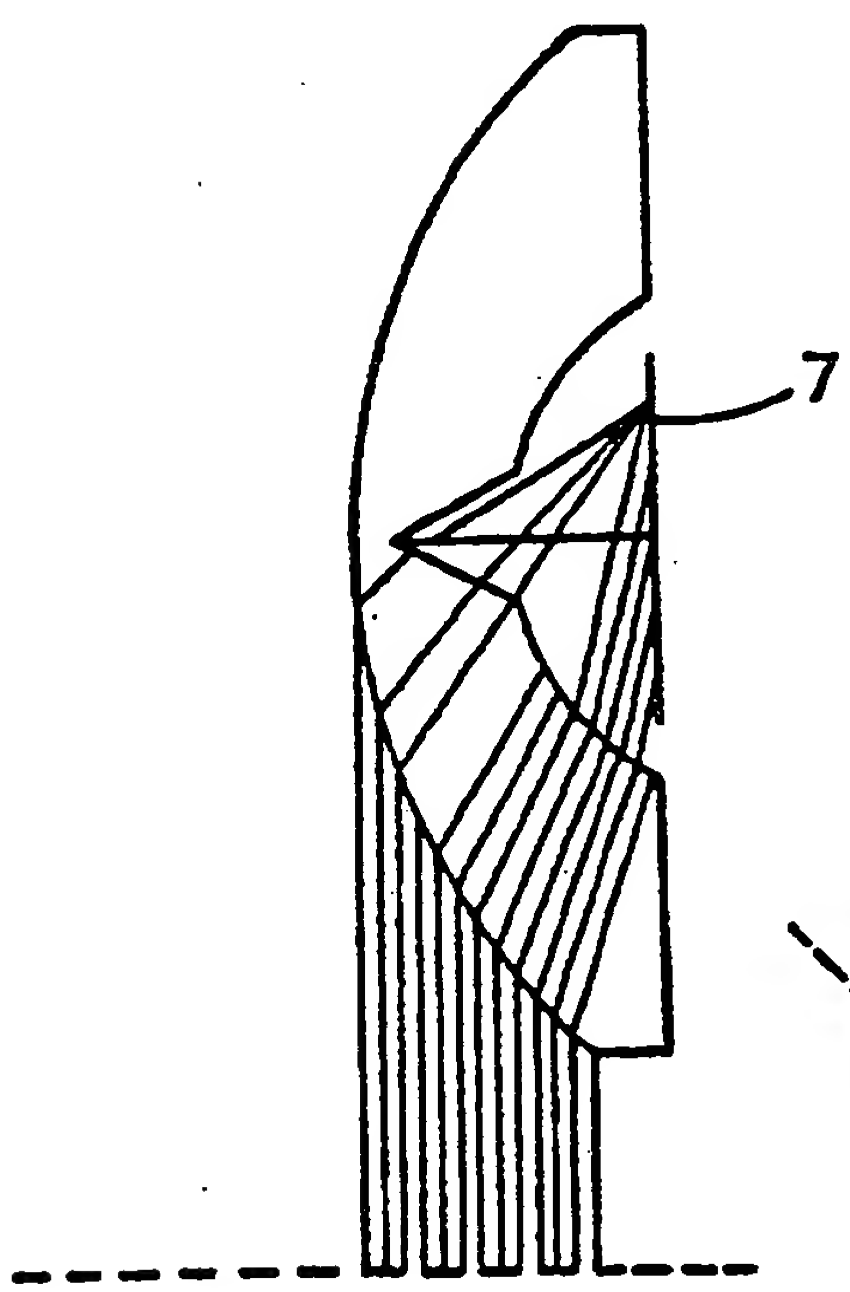


FIG. 4b

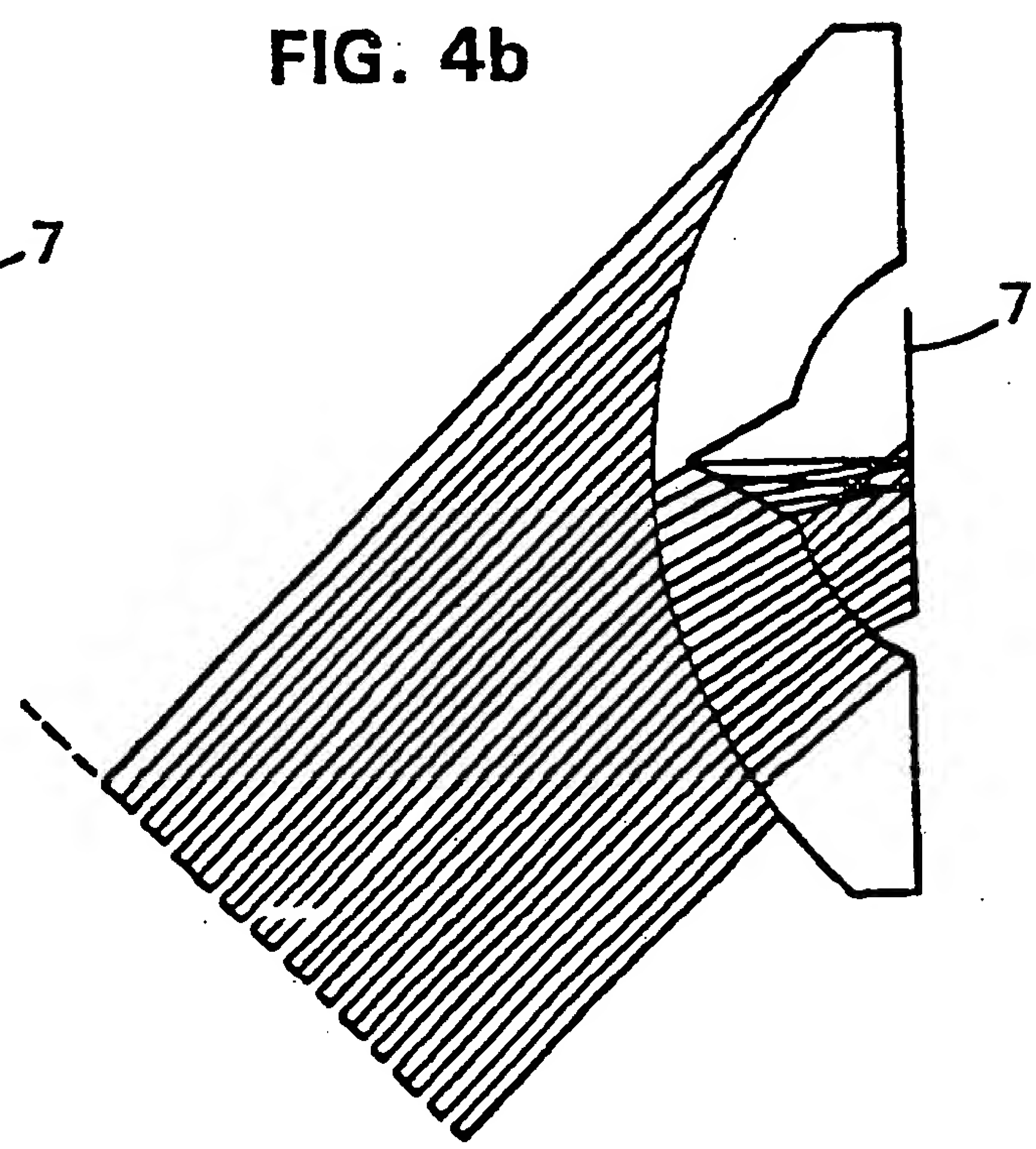


FIG. 5

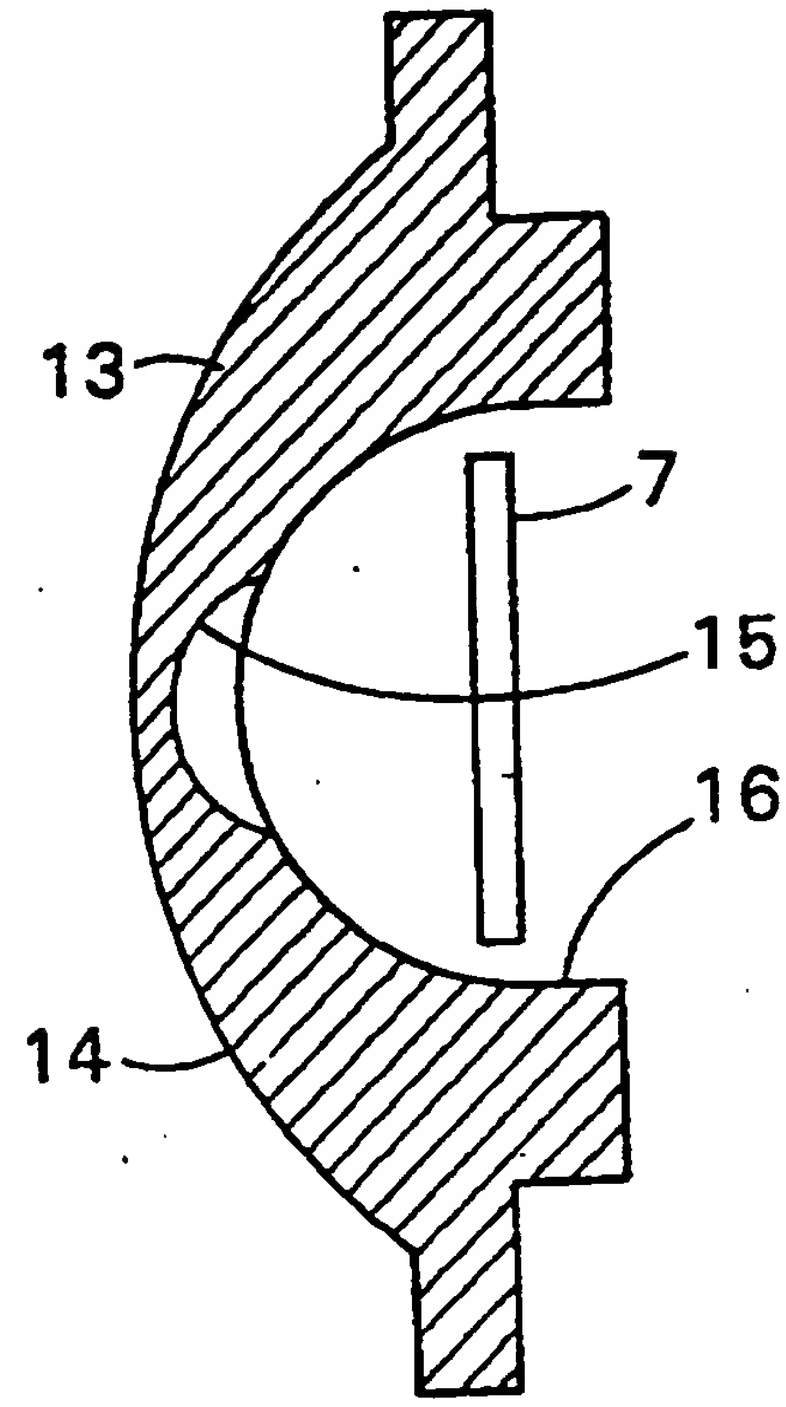


FIG. 3

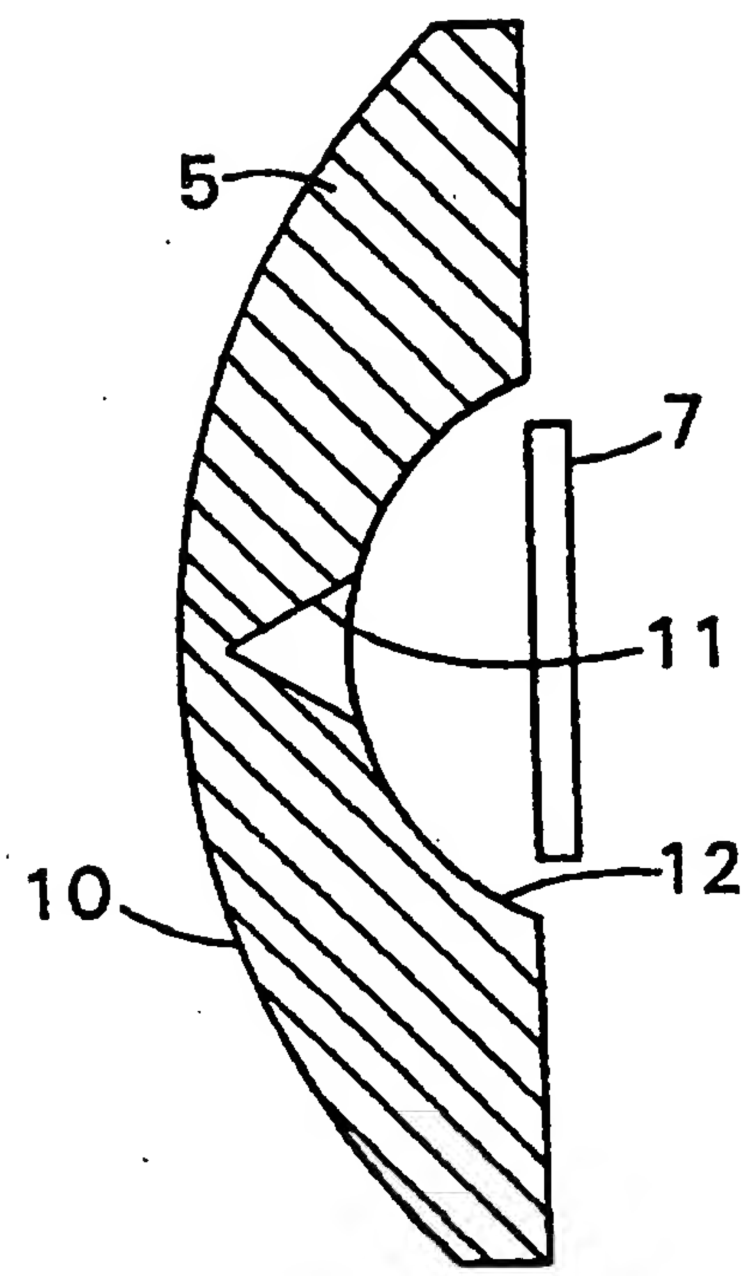


FIG. 6

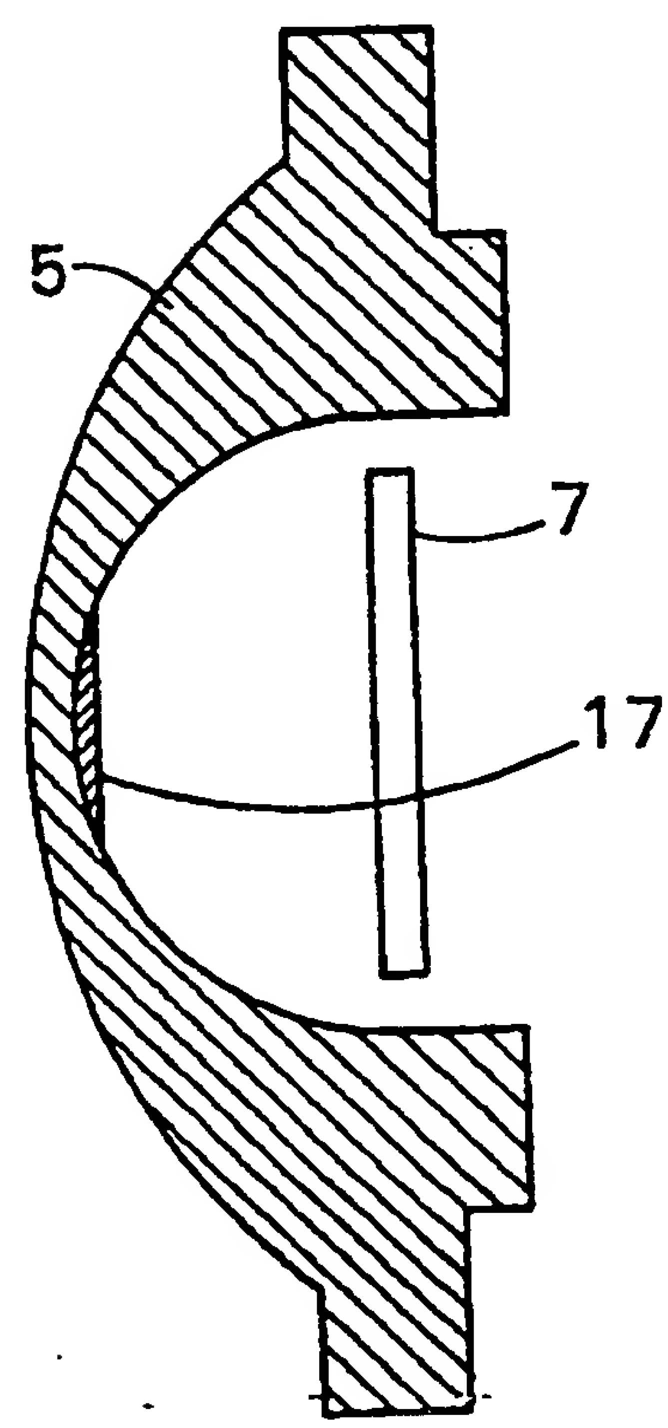


FIG. 7

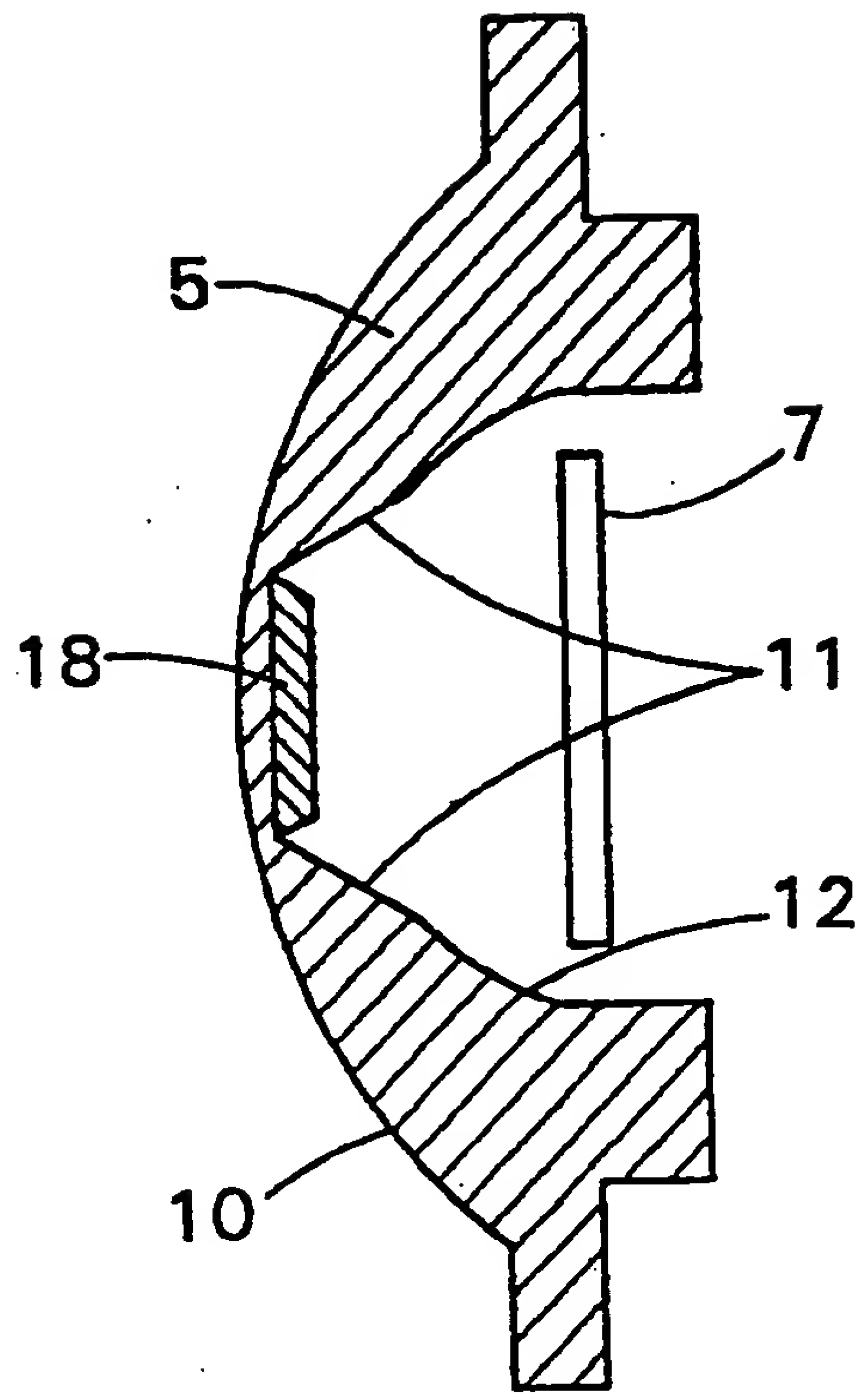


FIG. 8

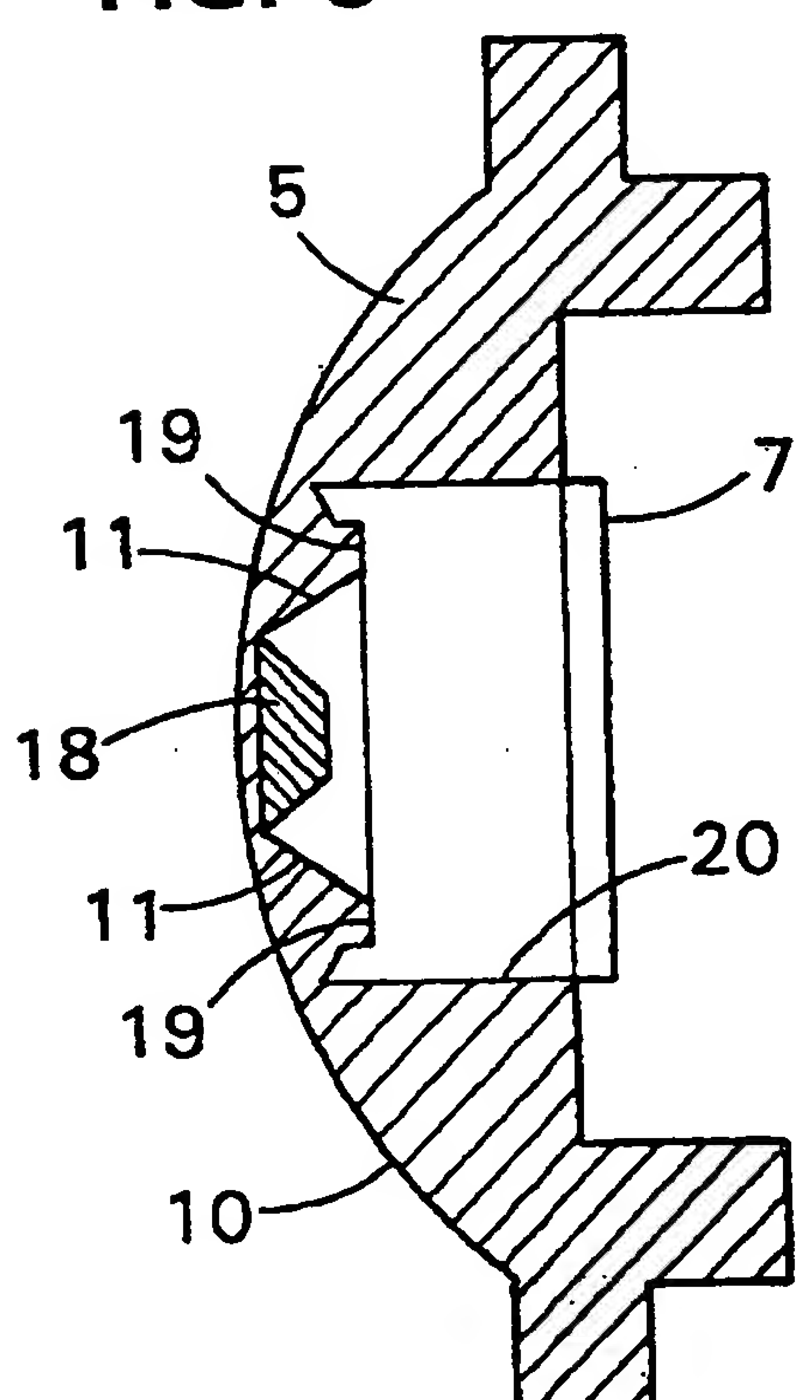


FIG. 9

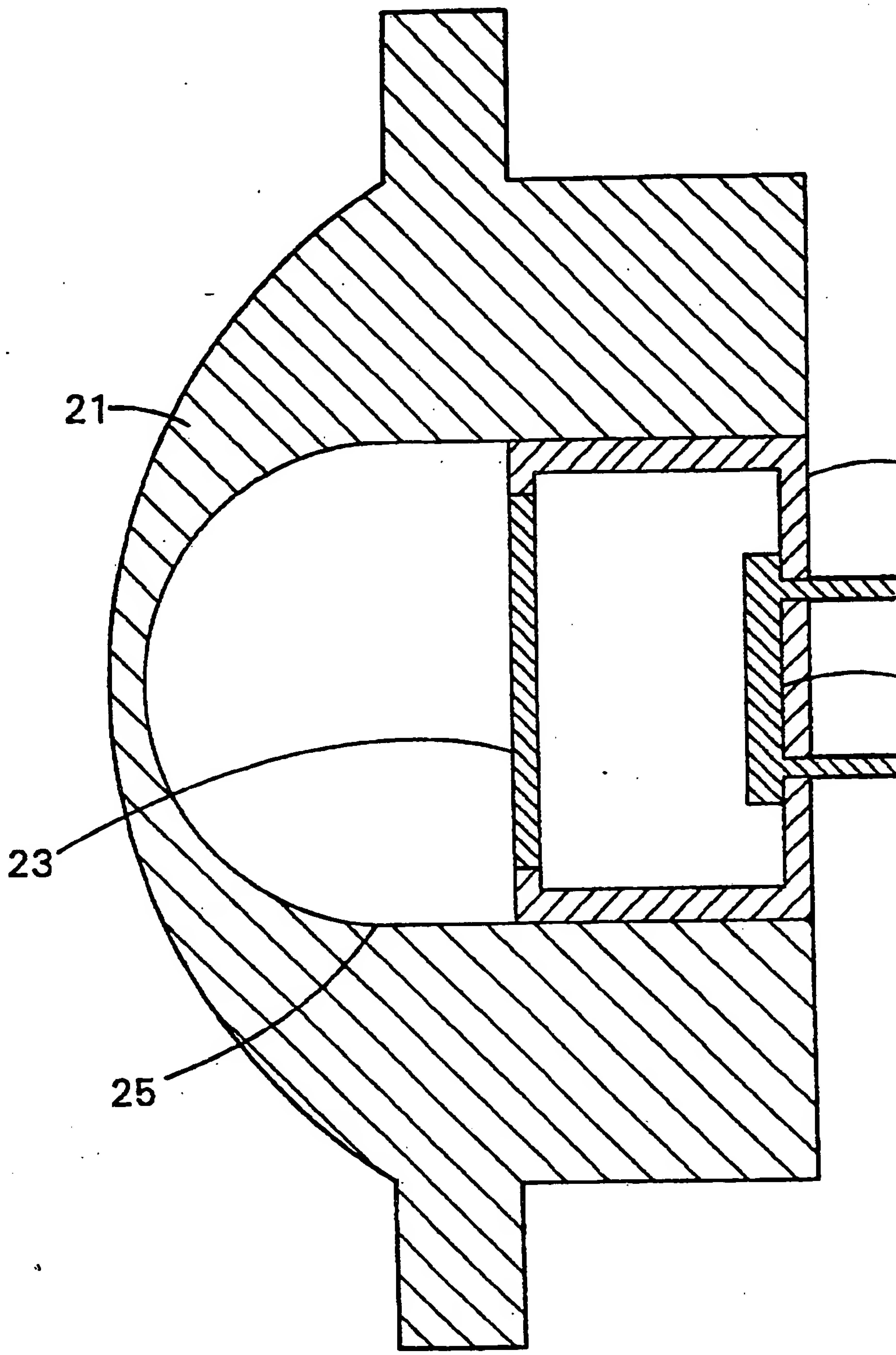


FIG. 10

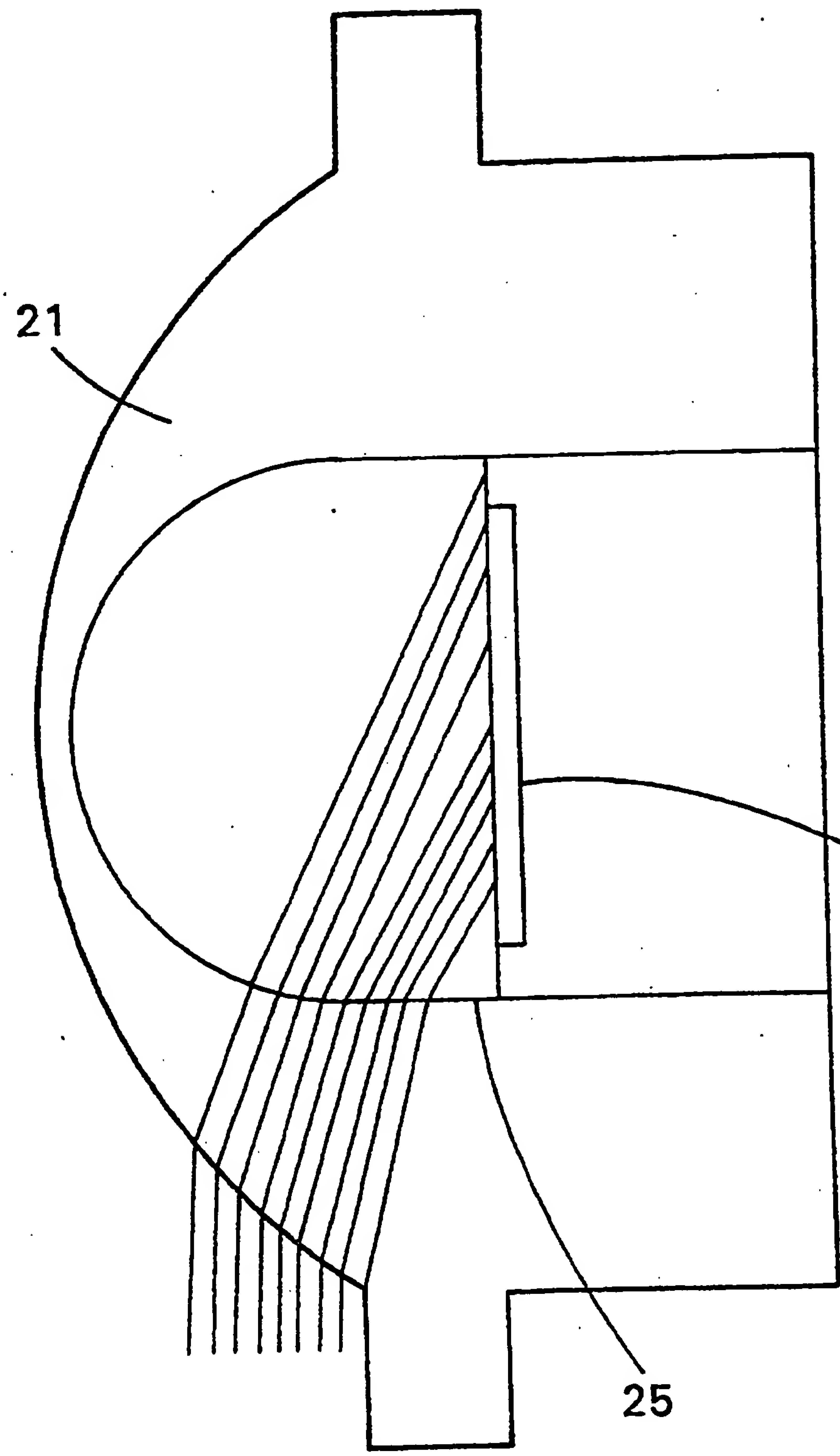


FIG. 11

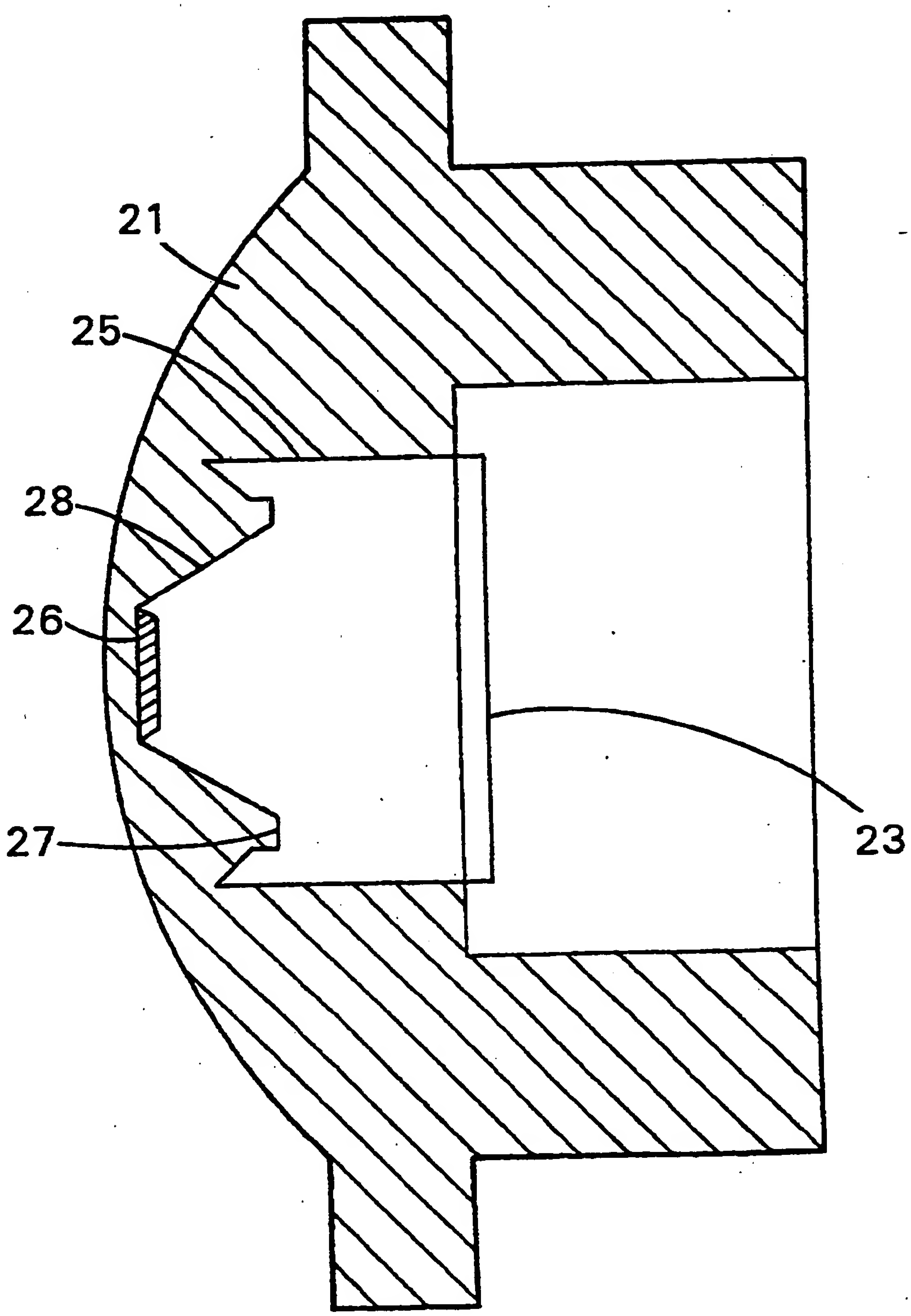


FIG. 12

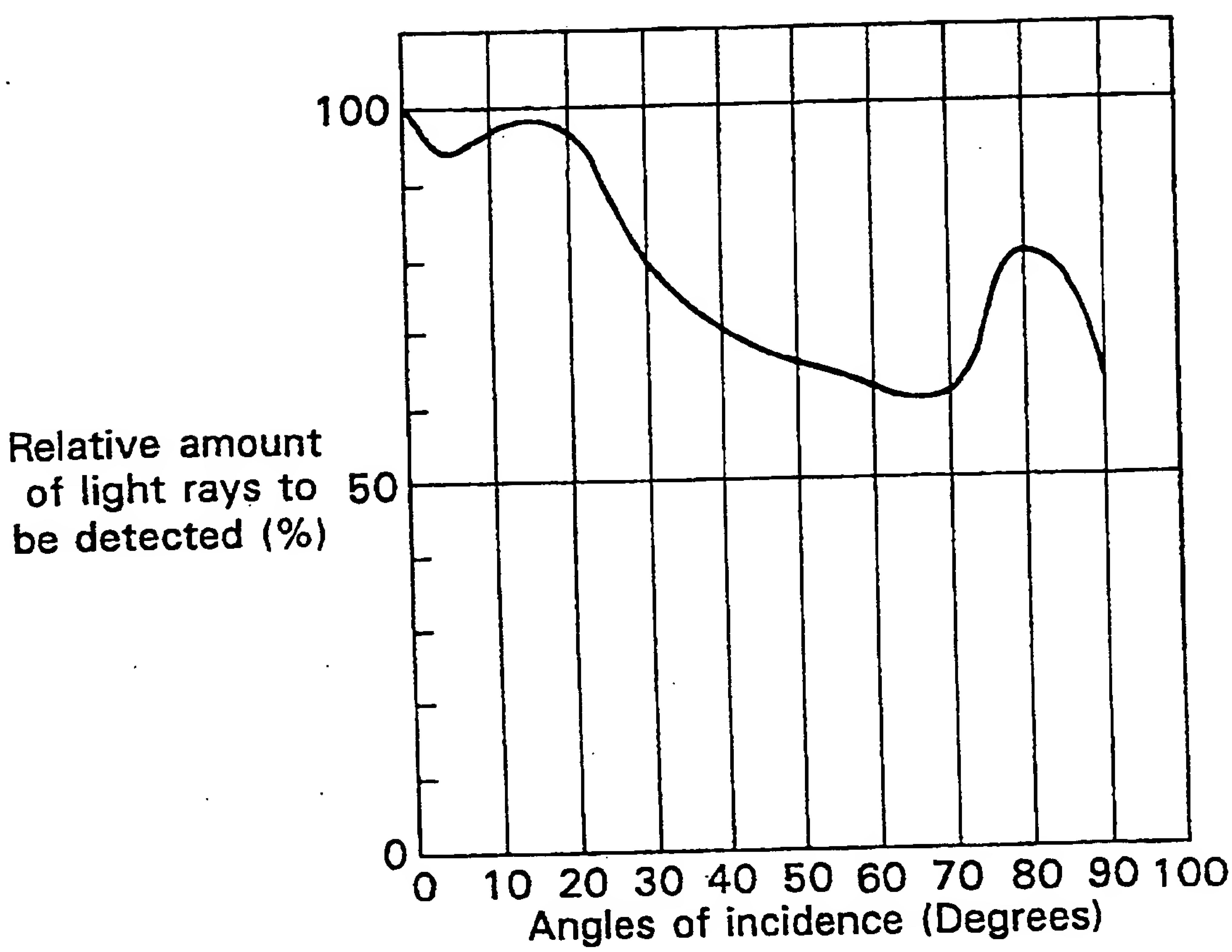

100
50
0
Relative amount of light rays to be detected (%)
0 10 20 30 40 50 60 70 80 90 100
Angles of incidence (Degrees)

FIG. 13

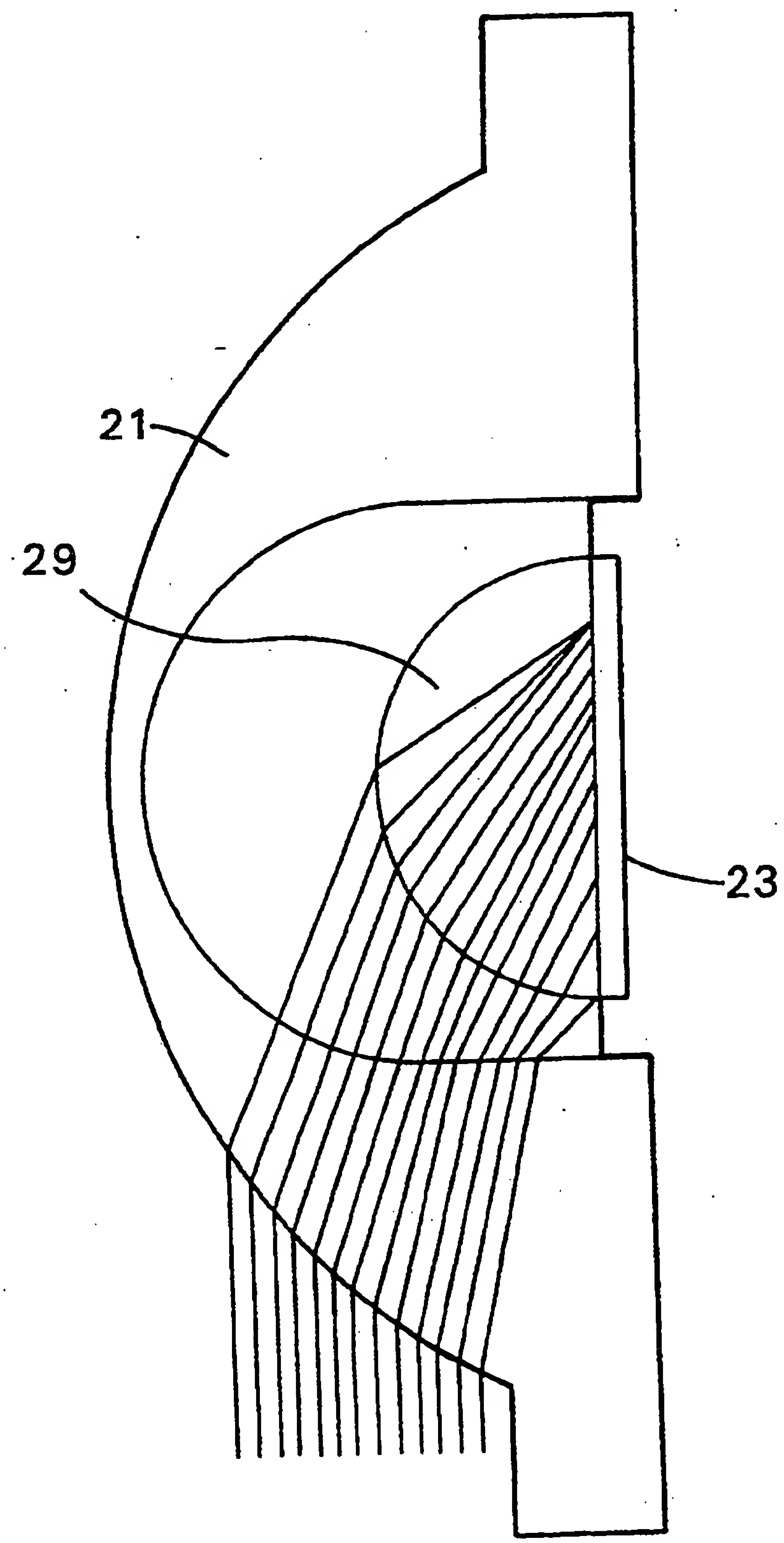


FIG. 14

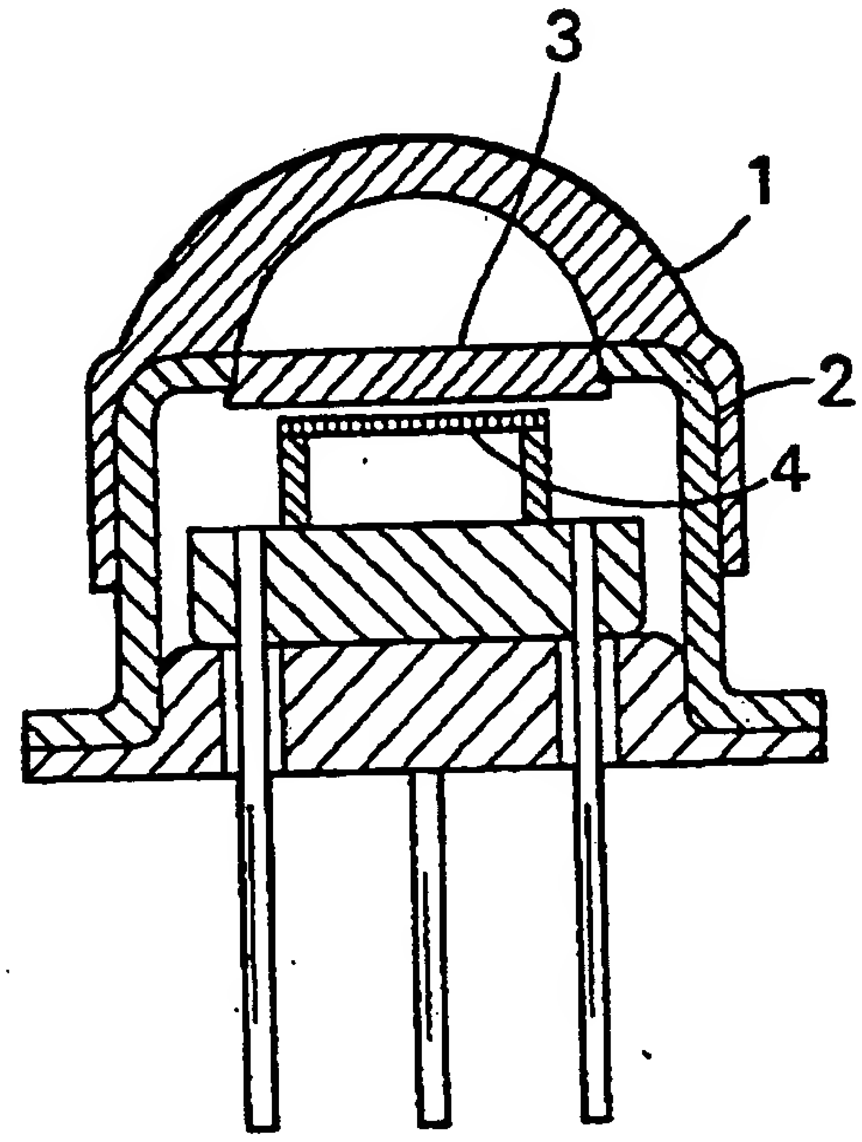
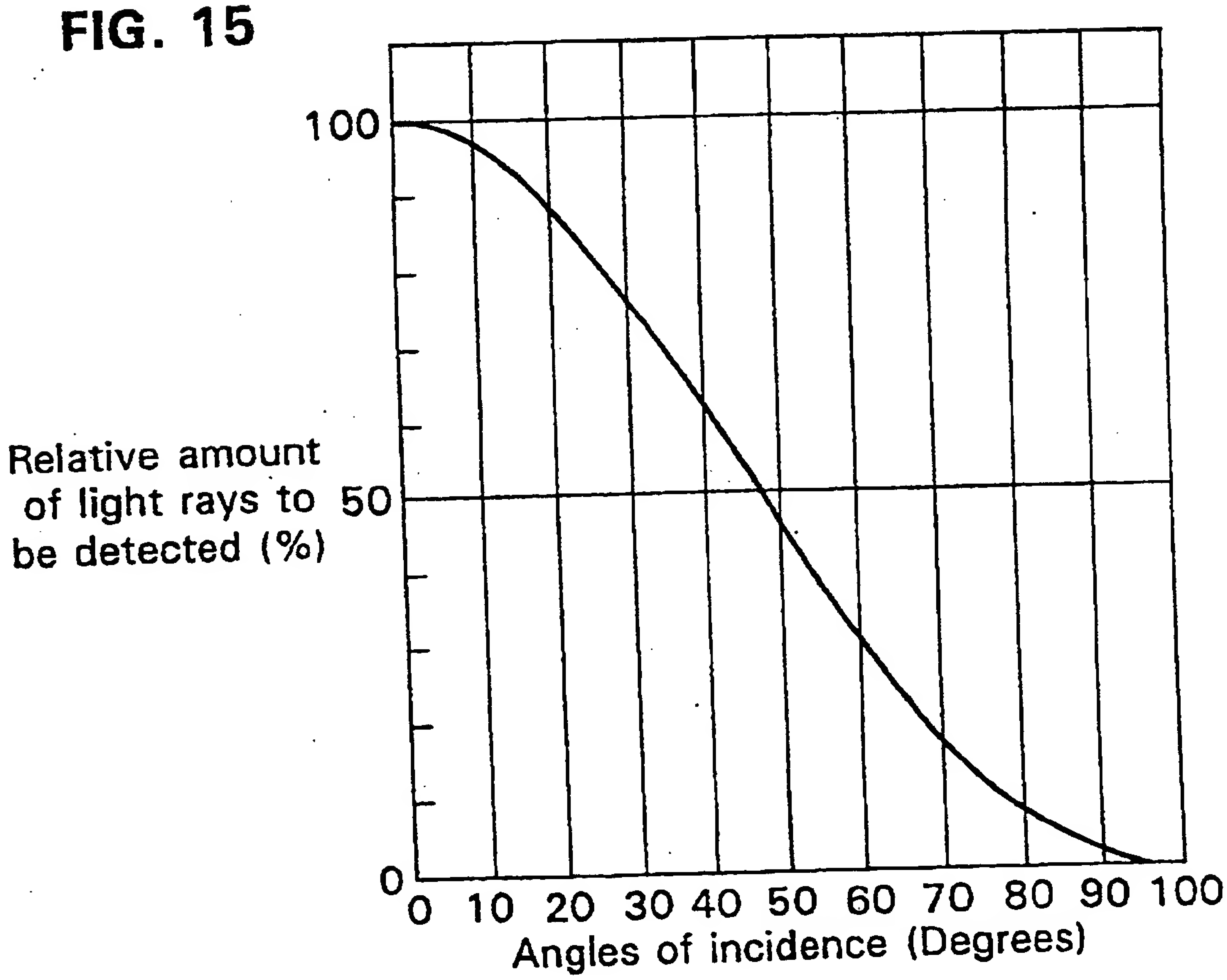

3
1
2
4

FIG. 15


100
50
0
Relative amount of light rays to be detected (%)
0 10 20 30 40 50 60 70 80 90 100
Angles of incidence (Degrees)

OPTICAL SENSOR

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an optical sensor which senses visible or infrared radiation and is used to control the operation of various devices or to measure the environment.

2. Description of the Prior Art

A conventional optical sensor of this kind has been described in Japanese Laid-Open Patent Publication No. 62-261025, which comprises, as shown in FIG. 14, a converging lens 1, a light detector 2, a transmitting window 3, and an optical sensor element 4. The converging lens 1 causes a light ray incident at right angles onto the light detector 2 to transmit therethrough without refraction and causes a light ray incident onto the light detector 2 at great angles of incidence to refract greatly, to thereby collect light rays from all directions onto the light detector 2.

In a constitution such as that mentioned above, most of the light rays incident at right angles onto the transmitting window 3 are detected. On the other hand, light rays incident in a horizontal direction onto the transmitting window 3 are refracted by the converging lens 1 and only a part of the light rays reaches the transmitting window 3. FIG. 15 shows the change in the amount of light detected with the angles of incidence at the time when the amount of the light to be radiated is maintained at a fixed level. Given that the amount of light to be detected on the optical axis of the converging lens (i.e., at the angles of incidence of zero degrees) is 100, when the angles of incidence are 90 degrees, that is, light rays are incident upon the converging lens 1 in the horizontal direction toward the transmitting window 3, the amount of light to be detected becomes zero. In this way, in the case that a conventional concave lens formed of a spherical surface is used as a converging lens, the amount of light to be detected is highly dependent upon the angles of incidence, which causes difficulties in accurate measurement of light amounts.

SUMMARY OF THE INVENTION

The optical sensor of this invention, which overcomes the above-discussed and numerous other disadvantages and deficiencies of the prior art, comprises a light detector, a converging lens located between said light detector and a light source, the light rays from which are detected by said light detector, and a light shielding means provided on a part of the converging lens, said shielding means shielding light rays emitted from said light source.

In a preferred embodiment, a part of the converging lens has a total reflection surface which totally reflects light rays incident thereupon.

In a preferred embodiment, a total reflection surface or shielding section that shields light rays alone entering into said converging lens with specific angles of incidence is disposed in a part of said converging lens.

Alternatively, the optical sensor of this invention comprises a light detector, a converging lens located between said light detector and a light source, the light rays from which are detected by said light detector, and a total reflection surface which totally reflects light rays thereupon, said total reflection surface being disposed in a part of said converging lens.

Alternatively, the optical sensor of this invention comprises a light detector, a converging lens located between said light detector and a light source, the light rays from which are detected by said light detector, and a cylindrical surface which is substantially parallel to the optical axis of said converging lens, said cylindrical surface being disposed in a part of said converging lens.

Thus, the invention described herein makes possible the objective of providing an optical sensor that has less dependence of the amount of light rays to be detected upon angles of incidence with which the light rays enter into the converging lens of the optical sensor.

BRIEF DESCRIPTION OF THE DRAWINGS

This invention may be better understood and its numerous objects and advantages will become apparent to those skilled in the art by reference to the accompanying drawings as follows:

FIG. 1 is a cross sectional view showing the optical sensor of a first embodiment of this invention.

FIGS. 2*a* to 2*c* are diagrams showing the state of light rays incident upon the converging lens of the optical sensor shown in FIG. 1.

FIG. 3 is a cross sectional view showing the main part of the optical sensor of a second embodiment of this invention.

FIGS. 4*a* to 4*c* are diagrams showing the state of light rays incident upon the converging lens of the optical sensor shown in FIG. 3.

FIGS. 5 to 8, respectively are cross sectional views showing the main parts of the optical sensors of third to sixth embodiments of this invention.

FIG. 9 is a cross sectional view showing the optical sensor of a seventh embodiment of this invention.

FIG. 10 is a diagram showing the state of light rays incident upon the converging lens of the optical sensor shown in FIG. 9.

FIG. 11 is a cross sectional view showing the main part of the optical sensor of an eighth embodiment of this invention.

FIG. 12 is a graph showing the result of an experiment of measurements of light amounts in the eighth embodiment of this invention.

FIG. 13 is a cross sectional view showing the optical sensor of a ninth embodiment of this invention wherein two converging lenses are used.

FIG. 14 is a cross sectional view showing a conventional optical sensor.

FIG. 15 is a graph showing the relationship between the light amounts and the incident angles in the optical sensor of FIG. 14.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

EXAMPLE 1

FIG. 1 shows an optical sensor of this invention, which comprises a converging lens 5, and a light detector 6 that is provided with a transmitting window 7 and an optical sensor element 8. A light ray shielding section 9 that has a configuration symmetrical with respect to the optical axis of the converging lens 5 is located on the optical axis of the converging lens 5. As shown in FIG. 2*a*, when the angles of incident are zero degrees, most of the light rays are shielded by the shielding section 9 and do not reach the transmitting window 7 of the light detector 6. As shown in FIG. 2*b*, on the other hand, a part of light rays with an incident angle of 45 degrees is

shielded by the shielding section 9. Furthermore, when the angles of incidence are 90 degrees as shown in FIG. 2c, the light rays are refracted greatly on the light source side of the converging lens 5 and, consequently, most of the light rays reach the transmitting window 7 without passing through the shielding section 9. As a result, the amount of light rays with smaller incident angles to be detected becomes smaller and the amount of the light rays with greater incident angles to be detected becomes relatively greater. This means that the difference in the detected amount of light rays based on the different angles of incidence can be reduced.

EXAMPLE 2

FIG. 3 shows the converging lens of another optical sensor of this invention, the converging lens 5 of this example is different from that of Example 1 as shown in FIG. 1, in that the entire converging lens 5 of this example is made of a single kind of material and is provided with a total reflection section 11, so that the effect which was attained by the converging lens with the shielding section of Example 1 can also be attained by this example. In FIG. 3, the reference numeral 10 is a surface of the converging lens facing a light source (not shown), 11 is a total reflection section formed in the surface of image forming side of the converging lens 5, and 12 is a spherical surface section on the image forming side of the converging lens 5. The converging lens 5 functions as follows: FIGS. 4a, 4b and 4c show light rays incident upon the transmitting window 7 at different incident angles. As shown in FIG. 4a, light rays with small incident angles are refracted by the total reflection section 11 and do not reach the transmitting window 7, and only the light rays passing through the spherical surface section 12 reach the transmitting window 7. Light rays with medium-sized or more angles of incidence, as shown in FIGS. 4b and 4c, most of the light rays, either incident upon the total reflection section 11 or upon the spherical surface section 12, reach the transmitting window 7. Moreover, because the light rays that reach the transmitting window 7 through the total reflection section 11 are incident upon the transmitting window 7 with incident angles smaller than those of the light rays that reach the transmitting window 7 through the spherical surface section 12, the detection efficiency of this optical sensor is improved. As a result, an optical sensor that has less dependence upon the incident angle can be provided using a monolithic lens of a simple structure made of a single material. Although this example discloses that one total reflection section 11 is provided at one portion of the optical axis of the converging lens 5, it can be located at a portion other than the optical axis or a plurality of total reflection sections can be provided at different positions.

EXAMPLE 3

FIG. 5 shows the converging lens of another optical sensor of this invention, wherein the reference numeral 13 is a converging lens, 14 is the light source side surface of the converging lens 13, 15 is a curved surface of the converging lens 13 on the image forming side, and 16 is an image forming side surface of the converging lens 13. The converging lens 13 functions as follows: Most of light rays with smaller incident angles to the converging lens 13 transmit through the surface 14 of the converging lens 13 on the light source side and the curved surface 15 of the converging lens 13 on the image forming side. The light source side surface 14 and the image plane side curved surface 15 form a concave lens of a small curvature, which causes incident light rays to spread over a large angle, thereby reducing the amount of light rays reaching the transmitting window 7. On the other hand, light rays with large incident angles are deflected greatly by the light source side surface 14 and the image forming side surface 16 of the converging lens 13 and reach the transmitting window 7 at small incident angles, thereby enabling efficient detection of the amount of light rays even when the absolute amount of light rays that enter into the transmitting window 7 is small.

EXAMPLE 4

FIG. 6 shows another optical sensor of this invention, which is different from the optical sensor of Example 1 in that the light-shielding section 17 of this example is disposed on the surface of the converging lens 5 on the image forming side.

EXAMPLE 5

FIG. 7 shows another optical sensors of this invention, which is the same constitution as that of Example 2 shown in FIG. 3, except that a light-shielding section 18 is provided in addition to the total reflection section 11. A greater effect can be attained in this example than that of Example 2.

EXAMPLE 6

FIG. 8 shows another optical sensor of this invention, which is also the same constitution as that of Example 2 shown in FIG. 3, except that a light-shielding section 18 and a plane section 19 for directing light rays that enter into the converging lens 5 with small angles of incidence are provided in addition to the total reflection section 11. A greater effect can also be attained in this example than that of Example 2. The reference numeral 20 is a side face section formed of a plurality of surfaces without using a spherical surface, and the respective surfaces effectively direct the light rays of different incident angles onto the transmitting window 7.

EXAMPLE 7

FIG. 9 shows another optical sensor of this invention, which comprises a converging lens 21 and a light detector 22. The light detector 22 is provided with a transmitting window 23 and an optical sensor element 24. A cylindrical surface 25 which is substantially parallel to the optical axis of the converging lens 21 is located on the light detector 22 side of the converging lens 21. As shown in FIG. 10, when the incident angles are 90 degrees, the light rays are refracted by the cylindrical surface 25 of the converging lens 21 toward the direction in which the incident angles becomes smaller than those of the light rays entering into the converging lens 21. Accordingly, the light rays pass through the converging lens 21 with the angles of incidence smaller than those of light rays entering into the converging lens 21, so that the light rays passing through the converging lens and the transmitting window 23 with small angles of incidence can be effectively detected by the optical sensor element 24, and the amount of light rays to be detected become relatively large. That is, the difference in the amount of light rays to be detected due to incident angles can be reduced.

EXAMPLE 8

FIG. 11 shows the constitution of a converging lens of another optical sensor of this invention, which is different from the converging lens 21 of Example 7 shown in FIG. 9, in that a light-shielding means 26 which shields light rays of small incident angles and a total reflection surface 28 which totally reflects light rays of small incident angles are provided in the vicinity of the optical axis of the converging lens 21, thereby further reducing the difference in the amount of light rays to be detected due to incident angles. The reference numeral 25 is a cylindrical surface which is substantially parallel to the optical axis of the lens 21 and 27 is a surface perpendicular to the optical axis of the lens 21. Light rays entering into the converging lens 21 with small incident angles are shielded by the shielding means 26 and the total reflection surface 28. The surface 27 which is perpendicular to the optical axis of the lens 21 is provided so as to transmit light rays therethrough that enter into the converging lens 21 with small incident angles. The amount of light rays which reach the optical sensor element of the optical sensor can be freely set by adjusting the surface areas of the shielding means 26, the surface 27 perpendicular to the optical axis of the lens 21, and the total reflection surface 28.

FIG. 12 shows the results of an experiment of measurements of light amounts by the use of the optical sensor of Example 8, wherein the maximum value of the amount of detected light rays is set to be 100.

FIG. 12 indicates that a nearly uniform amount of light rays is obtained for light rays with small incident angles, 40 degrees or less. Even the lowest amount of light rays detected is about 60% of the maximum value, which indicates a great improvement over conventional optical sensors.

Although a plane board that attains no lens effect was used as the transmitting window 23 in Examples 7 and 8, it can be a convex lens or, as shown in FIG. 13, it can be provided with a convex lens 29 as a second converging lens in front of it.

It is understood that various other modifications will be apparent to and can be readily made by those skilled in the art without departing from the scope and spirit of this invention. Accordingly, it is not intended that the scope of the claims appended hereto be limited to the description as set forth herein, but rather that the claims be construed as encompassing all the features of patentable novelty that reside in the present invention, including all features that would be treated as equivalents thereof by those skilled in the art to which this invention pertains.

What is claimed is:

1. An optical sensor comprising a light detector, a converging lens having an optical axis, said converging lens being located between said light detector and a light source, the light rays from which are detected by said light detector, and a light shielding means provided on a part of the converging lens in alignment with said optical axis thereof such that said shielding means shields only a center part of the light rays emitted from said light source.

2. An optical sensor according to claim 1, wherein a part of the converging lens has a total reflection surface which totally reflects light rays incident thereupon.

3. An optical sensor according to claim 1, wherein a total reflection surface or shielding section that shields light rays alone entering into said converging lens with specific angles of incidence is disposed in a part of said converging lens.

4. An optical sensor comprising a light detector, a converging lens having an optical axis, said converging lens being located between said light detector and a light source, the light rays from which are detected by said light detector, and a total reflection surface disposed in a part of said converging lens in alignment with said optical axis thereof such that said total reflection surface totally reflects only a center part of the light rays thereupon.

* * * * *

United States Patent [19]

Thomson

[11] 3,825,747

[45] July 23, 1974

[54] SCANNER

[76] Inventor: E. Craig Thomson, 55 Livingston Rd., Wellesley, Mass. 02181

[22] Filed: May 21, 1973

[21] Appl. No.: 362,117

[52] U.S. Cl. 250/216, 250/222, 356/172

[51] Int. Cl. H01j 3/14

[58] Field of Search ..... 250/216, 217 CR, 239, 221, 250/272; 356/172, 4, 152

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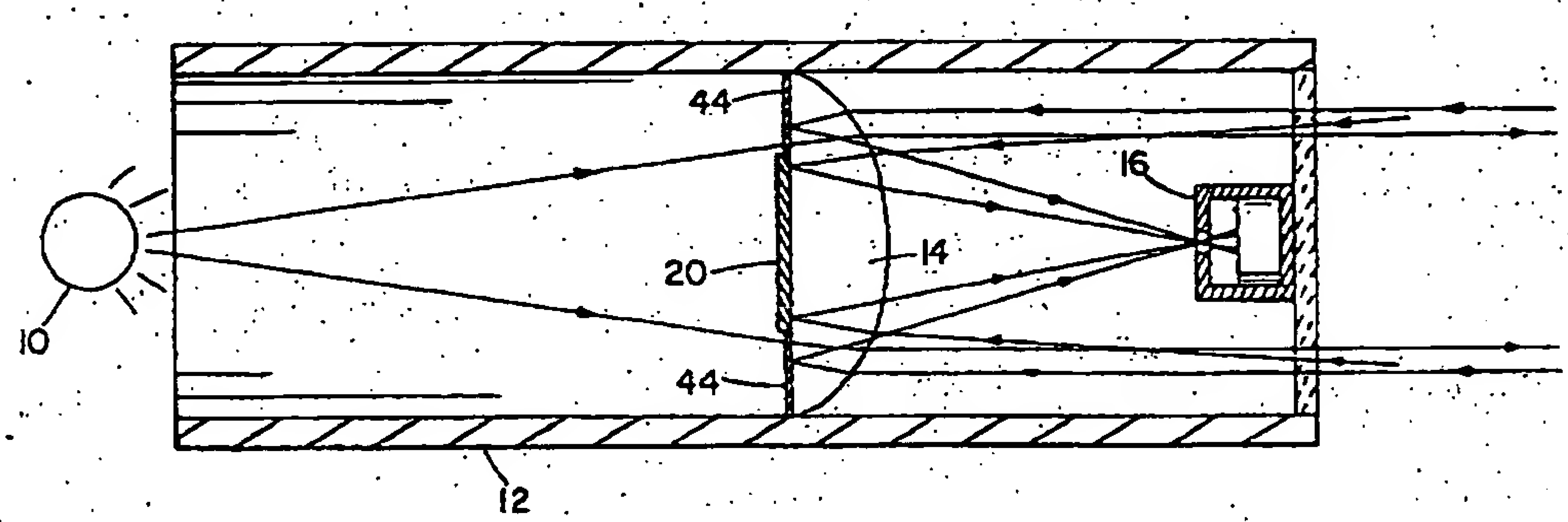
Primary Examiner—Walter Stolwein

[57] ABSTRACT

Scanning apparatus in which a sensor is mounted within a transceiver casing and a single focusing means both forms a beam from a radiation source for delivery to a target and focuses a returned beam onto the sensor. A forward looking reflective surface is included in the path of one of the beams, causing that beam to be twice passed through the focusing means. The sensor faces the radiation source, thus avoiding the need for a separate lens for the returned radiation. The scanner is particularly useful in detecting retro-reflective targets.

10 Claims, 6 Drawing Figures



PATENTED JUL 23 1974 3,825,747

FIG 1

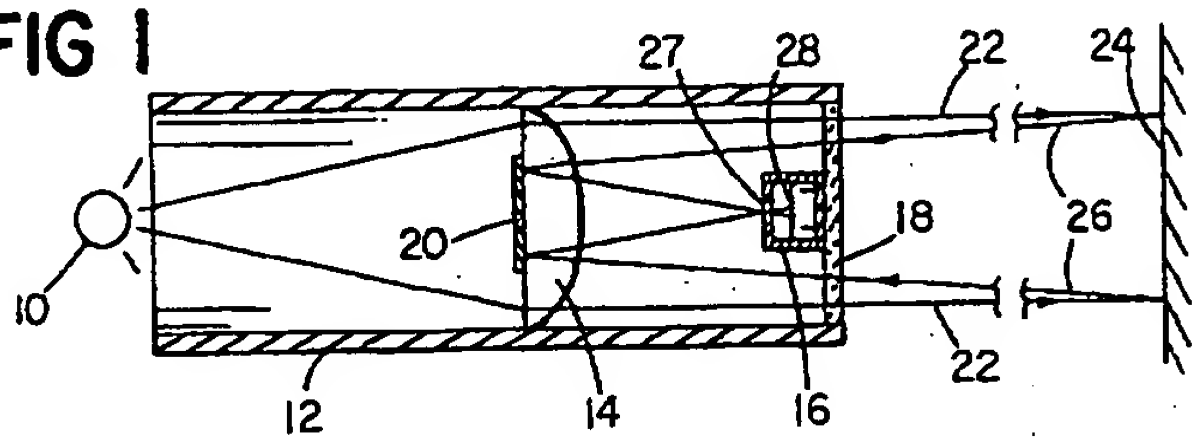


FIG 2

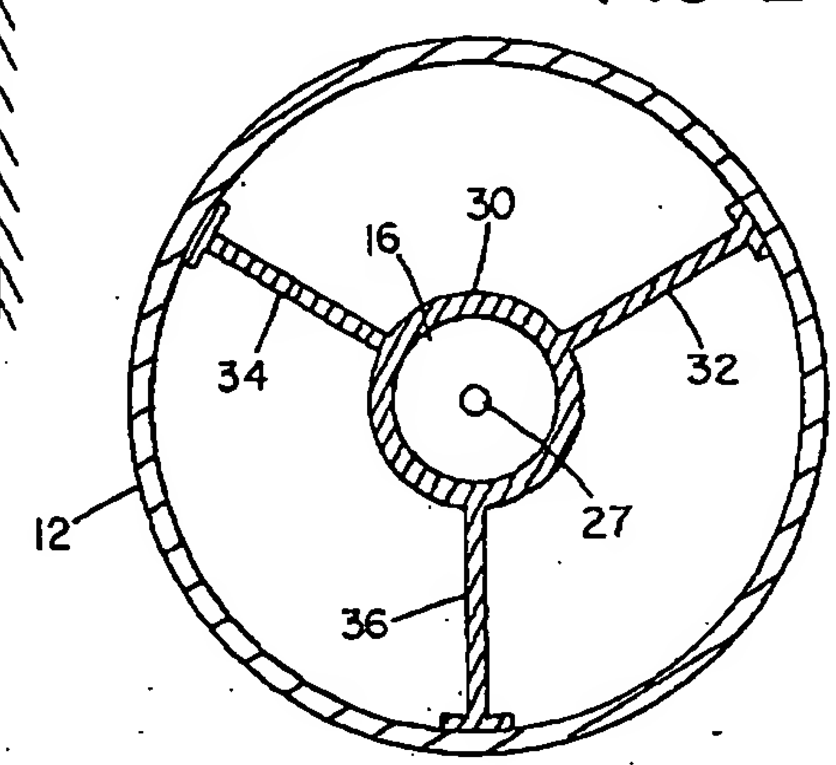
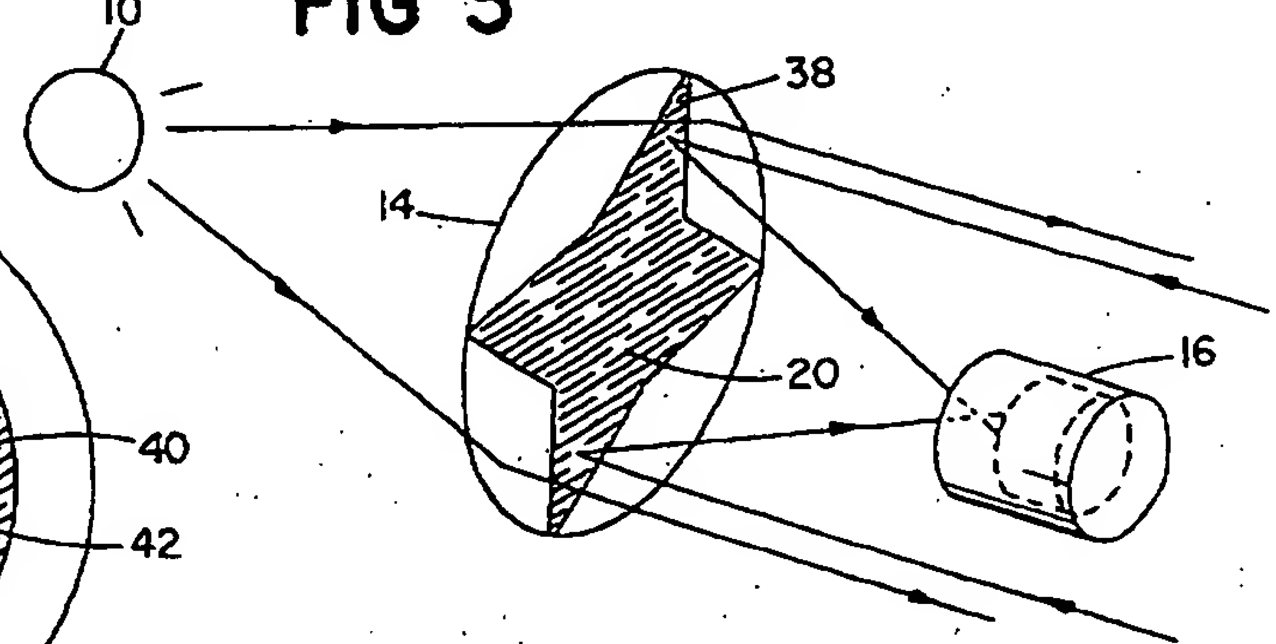


FIG 3



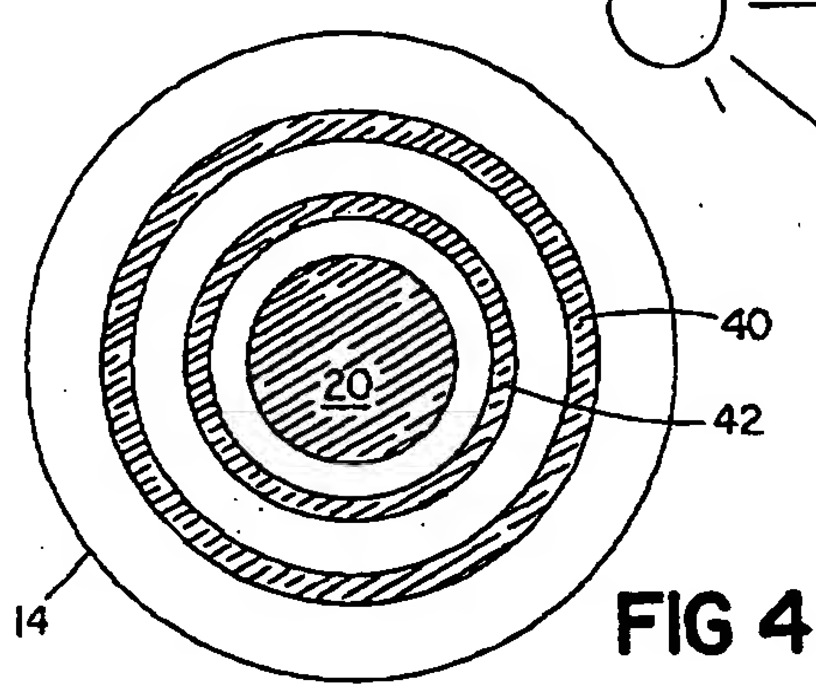


FIG 4

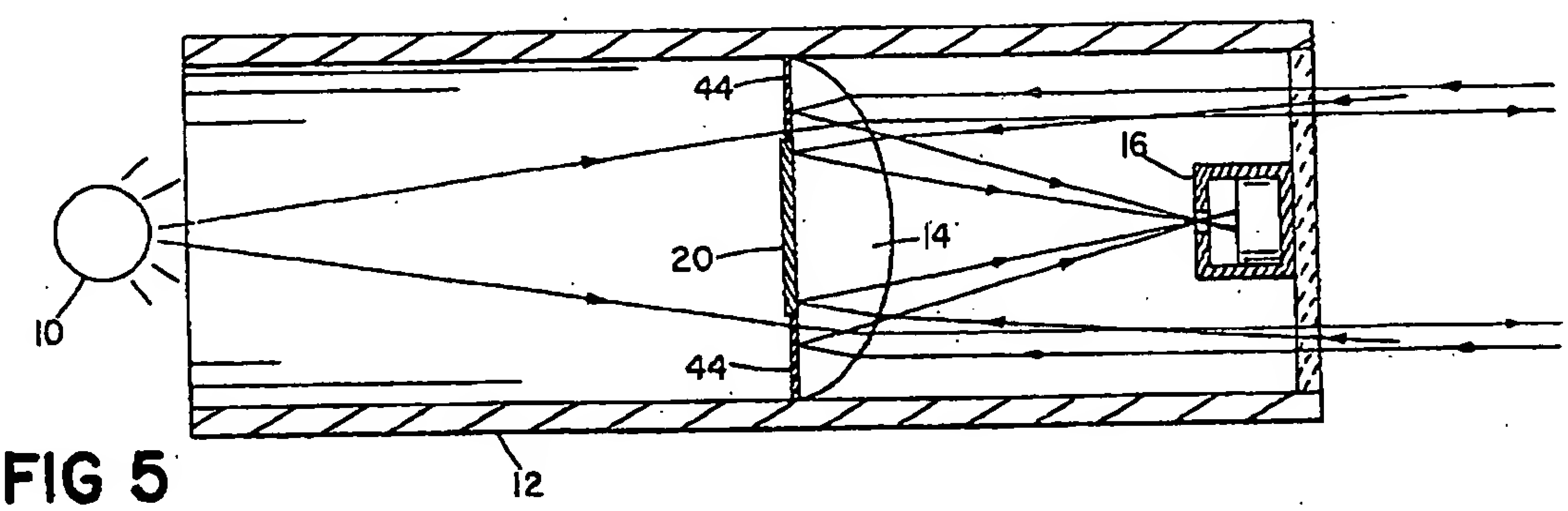


FIG 5

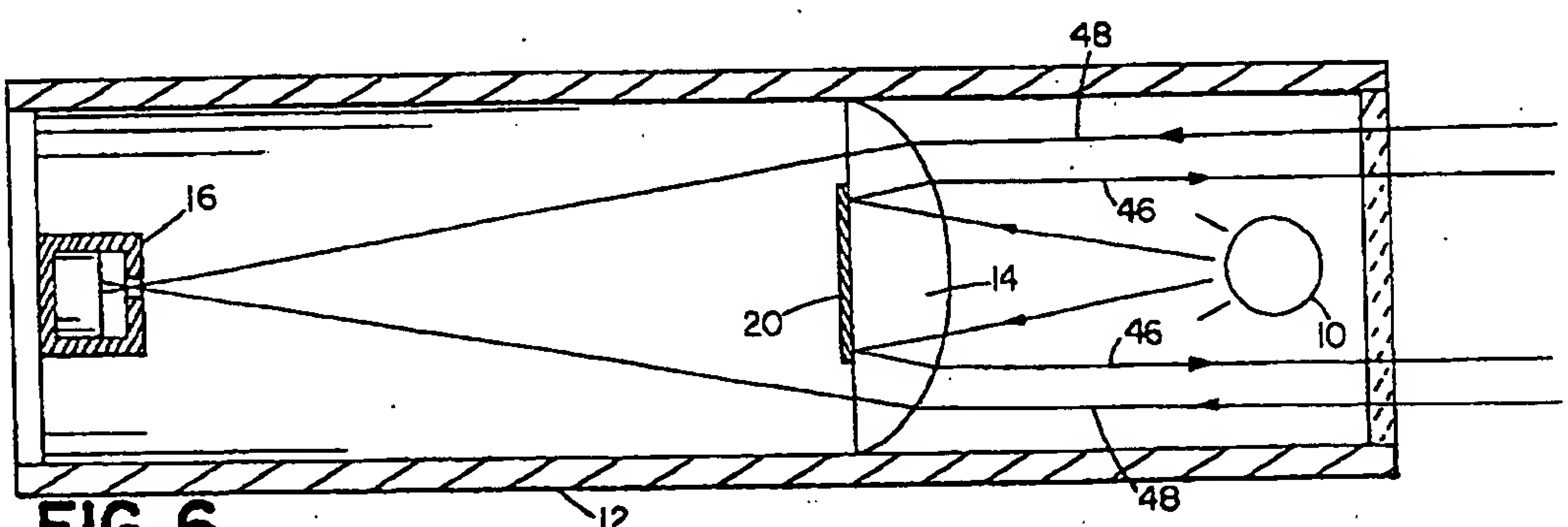


FIG 6

SCANNER

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to radiation sensing apparatus and more particularly to a scanning device having both a radiation beam source and a sensing unit for detecting reflections of the beam from a target.

2. Description of the Prior Art

In the past optical scanners with separate transmitting and receiving units have been used to detect targets in the beam path having particular reflective qualities. The requirement for separate units generally increased both the complexity and the bulk of the equipment, and rendered the apparatus more difficult to operate. The receiver had to be aligned in the path of the returning light and positioned with the correct angular orientation; when the transmitter and sensing units were separate entities this had to be done every time one of them was moved.

More recently a coaxial scanner has been developed in which a transmitter and sensing unit are mounted in the same casing. A beam is produced from the rear of the casing and transmitted around the sensing unit and out the front of the casing. Reflected radiation is returned back into the casing where it is focused by a lens held in the front of the sensing unit and converged onto the sensor. Combining the units into a single casing produced a highly accurate device that was more compact than previously available sensors.

While considerably improved over older models, the present coaxial scanners are still complex, and can be further simplified. Their sensing units are also subject to background radiation entering from outside the scanner.

SUMMARY OF THE INVENTION

In the present invention, a transceiver scanner has a unitary focusing means, one portion of which is used to form a beam for transmission to a target and another portion of which is used to focus a light beam reflected back for the target onto a sensor. The focusing means includes a reflective surface positioned in the path of one of the beams to reflect the beam back for a second passage through the focusing means. Radiation from the source that eventually reaches the sensor undergoes one reversal of direction at the target and another at the reflective surface, terminating in a direction such that the sensor faces the source to receive the radiation.

In a particular embodiment a member is mounted on the rear of the focusing means and includes a surface forming the reflective surface, the member in addition serving to shade the sensor from direct illumination by the radiation source. Depending on the shape of the member an outgoing beam is formed which occupies a cross-sectional area less than the cross-sectional area of the focusing means, the portion of the focusing means not involved in forming the outgoing beam being used to focus a returned beam onto the sensor. Instead of a single member on the focusing means a plurality of members may be employed, the size, shape and placement of the members being selected in accordance with the strength of outgoing beam and detection efficiency for the returned beam desired.

In one embodiment the radiation source is located to the rear of the focusing means, which is preferably a single plano-convex lens, and the sensor is in front and facing backward towards the source. An outgoing beam is formed around a member mounted on the rear of the focusing means. That portion of the beam reflected back from a target that strikes the focusing means at points not occupied by the outgoing beam is partially focused and directed onto the reflective surface, where it is reflected back through the focusing means and fully focused onto the sensor. In another embodiment the radiation source is in front of the focusing means, and the sensor is to the rear and facing forward towards the source. In this embodiment an outgoing beam is formed by radiation from the source that traverses the focusing means a first time, is reflected off the reflective surface, and passes back through the focusing means a second time. The area of the outgoing beam is substantially equal to the area of the reflective surface. Radiation is focused onto the sensor from that portion of the beam reflected back from a target that strikes the focusing means out of alignment with the reflective surface.

The member providing the reflective surface is situated in the optical line between the radiation source and sensor to shade the sensor, and in addition its size and shape are selected to give a desired balance between the outgoing beam strength and the sensing capability for a returned beam. The member may be either symmetrical or assymmetrical with respect to the focal axis, and in one embodiment a plurality of discrete members are provided to increase the sensing efficiency. Depending on the disposition of the member, the outgoing beam may also be either symmetrical or assymmetrical about the focal axis.

The scanner is particularly sensitive to targets characterized by small-angle scattering of reflected radiation, such as retro-reflective surfaces. It may also be used to detect diffuse-reflecting targets, for which its construction produces a large depth of focus.

Other objects, features and advantages of the invention will be seen from the following detailed description, in conjunction with the drawing, in which:

FIG. 1 is a diagrammatic illustration of a particular embodiment of the invention;

FIG. 2 is a sectional view showing one way of mounting the sensing unit;

FIG. 3 is an illustrative perspective view of a scanner having additional reflecting areas on the focusing means;

FIG. 4 is a rear view of a focusing lens having additional reflecting areas;

FIG. 5 is a diagrammatic illustration of a scanner having a one-way mirror deposited on the rear surface of the lens; and

FIG. 6 is a diagrammatic illustration showing another embodiment of the invention.

DETAILED DESCRIPTION OF PARTICULAR EMBODIMENTS

The present invention employs a lamp **10** as a source of radiation within a scanner casing such as tube **12** that houses a radiation focusing means **14**, and a radiation sensing unit **16**. The focusing means **14** is preferably provided by a single lens which, as illustrated in FIG. **1**, is as large as the inner diameter of the tube **12**, with a plane surface facing the radiation source **10** at

the rear, and a convex surface facing towards the front. The sensing unit **16** is mounted along the focal axis on a transparent glass plate **18** that keeps dust out of the tube. Lens **14** has deposited upon the central portion of its rear surface a member shown as disc **20**, the forward-facing surface of which is reflective and the rearward facing surface opaque to radiation from source **10**. Reflecting member **20** could also be provided separately from lens **14**, as by mounting it in the casing **12** between the lens and radiation source **10**, or a separate member could be provided to shade sensing unit **16** from radiation source **10**. It is preferable, however, to combine both functions in a single element mounted on the lens as shown in the drawings.

The radiation source **10** is located approximately one focal length behind the lens **14**, whereby light passing through the lens is formed into a substantially parallel beam. It may be desirable to place the radiation source **10** somewhat further to the rear in order to form a slightly convergent beam. As the reflecting member **20** is opaque to radiation transmitted from rear to front, an annular beam will be formed having a darkened interior portion corresponding approximately to the size of the member **20**, which is made large enough to shade the sensing unit **16** from direct illumination by the radiation source **10**. Outgoing radiation rays, indicated in FIG. 1 by numeral **22**, are reflected back into the scanner from a target such as retro-reflective surface **24**. The returning rays **26** travel back at a small angle of scatter characteristic of retro-reflective surfaces. That portion of the returning beam that strikes the lens **14** in optical alignment with reflecting member **20**, where the lens is not occupied by the outgoing beam, is refracted through the lens **14** onto the reflective surface of member **20**. These rays **26** are reflected off the member **20** and pass back through the lens, which focuses them onto the sensing unit **16**. Passing through a small aperture **27** in the unit, the rays **26** strike a photose..sitive surface **28** and initiate a signal that is brought out of the scanner through a pair of electrical leads (not shown). The sensing unit **16** is located about half a focal length in front of the lens **14**; a slightly smaller distance is preferred because of the somewhat converging nature of the returning rays **26**. As shown in FIG. 2, instead of being mounted on the front scanner plate **18**, the sensing unit **16** may be held in an inner cylindrical tube **30** which is supported coaxially with the axis of tube **12** by three thin webs **32, 34, 36**. The inner walls of the tube **12** may be dulled to reduce undesired radiation from entering the sensing unit **16**.

In the embodiment of FIG. 1 only a portion of the lens **14** is used in forming any outgoing transmitted beam. Reflection of radiation onto the sensing unit **16** is accomplished for that portion of the returned radiation that either strikes the interior portion of lens **14** involved in forming the transmitted beam or strikes lens **14** at a sufficiently large angle to the lens axis to be refracted onto the reflective surface of member **20**. The sensitivity of the scanner can be increased by adjusting the division of the lens into outgoing and returned beam portions in various ways. For example, as illustrated in FIG. 3, reflecting arms **38** extending outwardly from the reflecting member **20** may be deposited onto the rear of lens **14**. A transmitted beam will be formed from radiation passing from source **10** between the arms **38**. In addition to inwardly scattered return radiation is reflected off the arms **38** and focused onto the sensing unit **16**. While a greater proportion of the returned beam is delivered to sensing unit **16** due to the greater interface between outgoing and returned beams in this embodiment, it will be seen that the orginally transmitted beam is diminished by te presence of arms **38**. Depending upon the ultimate use planned for the scanner, an appropriate balance between beam strength and detection efficiency can be designed.

In FIG. 4 another arrangement is shown in which discrete concentric reflecting rings **40, 42** are deposited onto the rear of lens **14**. Radiation passes out between the rings **40, 42**, and return radiation is reflected from them onto the sensing unit **16**. Additional modifications in the shape of the reflecting surface may be envisioned both symmetrical and assymmetrical. For example, member **20** may bisect the lens **14** into upper and lower portions, or member **20** may occupy one side only of the lens. Similarly, it is not essential that the radiation source **10** and sensor **16** be located on the focal axis, as an off-center portion of lens **14** may be used to form the outgoing beam.

In another embodiment illustrated in FIG. 5, a semitransparent mirror **44**, adapted to transmit a certain proportion of radiation from the source **10** towards the front of the tube and to reflect returned radiation back trhough the lens **14** and onto the sensing unit **16**, is placed on the rear of the lens **14** around the reflecting member **20**. In this embodiment a high efficiency in sensing return radiation is achieved, in which virtually all radiation entering the scanner from a target is focused onto the sensing unit. However, mirror **44** does not fully transmit all the incident light from source **10**.

The scanner of this invention achieves a high degree of compactness and simplicity. When the radiation source **10**, lens **14** and sensing unit **16** are once aligned along the focal axis, no further alignment is necessary when the direction of the scanner is changed. Because of its sensitivity to small-angle scattering from a target, the scanner may be used to discriminate between retro-reflective targets and other surfaces; in its coaxial embodiment radiation retro-reflected from a target at a very close range can be recognized. The sensitivity of the photo-cell **28** may be selected such that the scanner can also detect diffuse-reflected radiation. In this mode the coaxial arrangement achieves a large depth of focus.

While preferred embodiments of the invention have been shown and described, various modifications thereof may occur to those skilled in the art. For example, a scanner is shown in FIG. 6 in which the position of the radiation source **10** and the sensing unit **16** have been reversed with respect to the lens **14**. The source **10** is displaced from the lens by about half a focal length, forming a substantially parallel outgoing beam **46** when radiation from the source **10** passes through the lens **14**, is reflected off of member **20** and again traverses the lens **14** on its way out the tube. Returned radiation **48** that strikes the lens **14** out of focal alignment with the member **20** is focused onto the sensing unit **16**, located approximately one focal length to the rear or slightly further away to compensate for the small divergence from a parallel beam of the return radiation **48**. The sensing unit **16** is shaded from source **10** by the reflecting member **20**, again making possible a very large signal to noise ratio.

It is therefore not intended that the invention be limited to the disclosed embodiments or details thereof, and departures may be made therefrom within the scope of the invention as defined in the claims.

What is claimed is:

1. A scanner comprising:
a. a radiation source;
b. a radiation sensor mounted facing said radiation source;
c. focusing means mounted between said radiation source and radiation sensor, a member mounted on the rear of the focusing means and shading said sensor from direct illumination by said source, said member having a forward facing reflective surface, said focusing means directing an outgoing beam from said source towards a target in front of said focusing means, said focusing means adapted to focus onto said sensor a beam reflected back from a target and incident on said focusing means at points not occupied by said outgoing beam, and said forward facing reflective surface being disposed in the path of one of said beams.

2. A scanner according to claim 1 useful in the detection of a target having a retro-reflective surface.

3. A scanner according to claim 1 wherein said focusing means is adapted to form an outgoing beam having an unoccupied central portion.

4. A scanner according to claim 1, wherein said source is to the rear of said focusing means, said sensor is in front of said focusing means, and the cross-sectional area occupied by said outgoing beam is substantially equal to the cross-sectional area of said focusing means excluding the cross-sectional area of said shading member.

5. A scanner according to claim 1 wherein said source is in front of said focusing means, said sensor is to the rear of said focusing means, and the cross-sectional area occupied by said outgoing beam is substantially equal to the area of said reflective surface.

6. A scanner according to claim 1 wherein said focusing means is a plano-convex lens.

7. A scanner for casting radiation forward onto a target and sensing radiation reflected back from the target comprising:
a. a light source;
b. a plano-convex lens mounted in a casing approximately a focal length of said lens in front of said source;
c. a light sensor mounted in said casing approximately one-half focal length of said lens in front of said lens; and
d. a member on the rear of said lens having an opaque rear surface shading said sensing unit from said light source, said member also having a reflective front surface for reflecting a portion of the light returned from a target back through said lens onto said sensing unit.

8. A scanner according to claim 7 wherein said light sensor is mounted on a transparent plate at the front of the casing.

9. A scanner according to claim 7, including a plurality of discrete members on the rear of said lens having reflective front surfaces.

10. A scanner according to claim 7 wherein said member is a semi-transparent mirror for transmitting light from said source to a target and for reflecting light returned from a target back through said lens onto said light sensor.

* * * * *

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,825,747 Dated July 23, 1974

Inventor(s) Elihu C. Thomson

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Title Page, before "Filed:", insert --Assignee: Electronics Corporation of America, Cambridge, Mass.--

Column 4, line 5, change "te" to --the--;
line 27, change "trhough" to --through--.

Signed and sealed this 29th day of October 1974.

(SEAL)
Attest:

McCOY M. GIBSON JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents

*** ACTIVITY REPORT ***

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